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DANA'S WORKS.

IVISON, BLAKEMAN, TAYLOR & Co., New York.—**Manual of Geology,** by J. D. DANA. **Third Edition,** 1880. 912 pp. 8vo. $5.00.—**Text-book of Geology** by the same. **4th ed.** 1883. 412 pp. 12mo. $2.00.—**The Geological Story Briefly Told,** by the same. 264 pp. 12mo. 1875.

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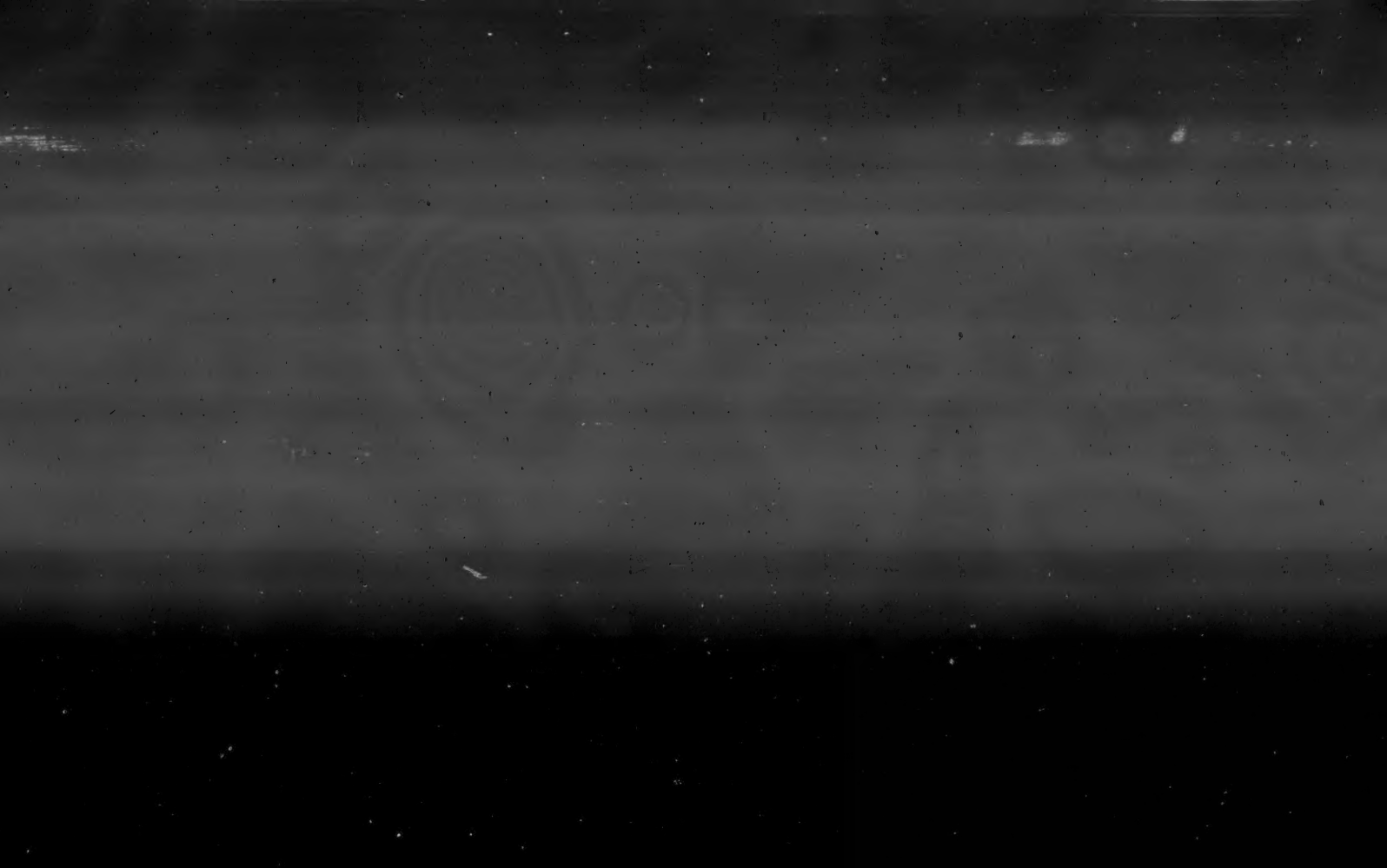

THE

AMERICAN JOURNAL OF SCIENCE.

[THIRD SERIES.]

ART. XXXVI.—*On Red and Purple Chloride, Bromide and Iodide of Silver; on Heliochromy and on the Latent Photographic Image;* by M. CAREY LEA, Philadelphia. Part I.

IN this series of papers it will be my object to show:

(1.) That chlorine, bromine and iodine are capable of forming compounds with silver exhibiting varied and beautiful coloration, peach-blossom, rose, purple and black. That these compounds (except under the influence of light) possess great stability: that they may be obtained by purely chemical means and in the entire absence of light.

(2.) That of these substances the red chloride shows a tendency to the reproduction of colors. It seems not improbable that the material of the infinitesimally thin films obtained by Becquerel, Niepce de St. Victor, Poitevin and others in their experiments on heliochromy may be the red chloride.

(3.) That these substances, formed by purely chemical means, constitute the actual material of the latent or invisible photographic image, which material may now be obtained in the laboratory without the aid of light and in any desired quantity. They also form part of the visible product resulting from the action of light on the silver haloids.

For more than a generation past, the nature of the latent photographic image, that which forms the basis of development, has been in dispute. Two theories have been maintained.

According to the one, the first effect produced by light is simply a physical change, predisposing the elements of the silver haloid to dissociation, so that when a reducing agent is applied, the molecules so affected, yield more quickly to its influence. According to the other theory, the invisible image is formed of a sub-salt (sub-chloride, etc.). Observations which I published many years ago led me strongly to the first-mentioned of these theories. But of late years, results have been obtained not easily reconcilable with it. On the other hand, the theory that the latent image is formed of subsalt is opposed to striking facts. Silver subchloride for example is an unstable substance, quickly destroyed by dilute nitric acid. But I have formed a latent image on silver chloride and after exposing it for five minutes to the action of strong nitric acid (sp. gr. 1·36) have developed the image without difficulty: the same with silver bromide. Evidently these images, which so strongly resisted the action of undiluted acid could not be formed of simple subchloride and subbromide of silver, substances quickly destroyed by it.

In the desire to find a satisfactory explanation of the nature of the image based on adequate chemical proof, I have devoted nearly three years of laboratory work to this and to closely allied subjects. I am led to the conclusion that neither of the older views is correct. A truer theory seems to be deducible from the result of some experiments which I published in 1885, to the effect that the silver haloids were capable of uniting with certain other substances, much in the same way that alumina forms lakes. When a silver haloid was precipitated in the presence of certain coloring matters they combined with it, and though soluble in water, they could not be subsequently washed out. They had formed a somewhat stable compound, although the proportion of coloring matter was very small in comparison with the haloid; evidently much too small to represent a stoichiometrical composition.

Now I find that a silver haloid may in the same way, unite with a certain proportion of its own subsalt, which by this union quite loses its characteristic instability and forms a compound of great permanence.

Another explanation is possible: the subsalt may combine with the normal salt, not in the manner above described, but in stoichiometrical proportion, and this compound may be diffused through ordinary silver haloid. I have not been able to find any reaction decisive between these explanations,* but the general behavior of the substance seems rather to indicate the

* Silver chloride may be dissolved out by hot solutions of sodium or ammonium chloride, but the subchloride is at the same time decomposed. See beyond under head of "Reactions."

first named explanation as the true one. When the red chloride, for example, has been boiled with dilute nitric acid for a few moments to eliminate any uncombined subchloride, the proportion of subchloride left has never exceeded 8 or 9 per cent in over thirty specimens analyzed. If we took this to represent a compound in equivalent proportions, we should have to suppose the union of at least twenty equivalents of AgCl with one of Ag_2Cl, which is improbable. If we suppose that these colored substances containing from less than one-half per cent up to eight or nine per cent of Ag_2Cl consist of a compound of one equivalent of subchloride united to a small number of equivalents of normal chloride, mixed mechanically with a large quantity of normal chloride, then it would be improbable that specimens could not be obtained containing a larger proportion of this compound and consequently of Ag_2Cl, but as already said, specimens containing more than 9 per cent after thorough treatment with nitric acid to remove the uncombined subchloride I have never obtained: generally the amount is less.

Even when silver chloride, bromide or iodide contains as little as one-half of one per cent of subsalt combined, its properties are greatly changed. It has a strong coloration and its behavior to light is altered. Even a much less quantity, one inappreciable to analysis, is capable of affecting both the color and the behavior to light.

It is one of these latter forms of this substance that constitutes the actual material of the latent photographic image: adequate proof of this will be given in the second part of this paper.

Red Silver Chloride.

Of the three haloids, the chlorine salt is the most interesting, because of its relations to heliochromy; it is also the most stable of the three compounds and exhibits perhaps a finer variety of coloration, though the bromide and iodide are also obtainable of very beautiful tints. The chloride shows all the warm shades from white to black through the following gradations: white, pale flesh color, pale pink, rose color, copper color, red purple, dark chocolate, black.

These compounds are obtained in an endless variety of ways: by chlorizing metallic silver; by acting on normal chloride with reducing agents; by partly reducing silver oxide or silver carbonate by heat and treating with HCl; by forming suboxide or a subsalt of silver and treating with HCl followed by nitric acid; by acting on subchloride with nitric acid or an alkaline hypochlorite, etc.; by attacking almost any soluble salt of silver with ferrous, manganous or chromous oxide, etc., fol-

lowed by HCl; by reducing silver citrate by hydrogen and treating it with HCl; by treating a soluble silver salt or almost any silver solution with potash or soda and almost any reducing agent, cane sugar, milk sugar, glucose, dextrine, aldehyde, alcohol, etc., and supersaturating with HCl; there is no organic easily oxidizable substance that I have tried that has failed to give this reaction. Also almost any salt of silver exposed to light, treated with HCl and then with hot strong nitric acid yields it. Almost any of these classes represents a long range of reactions, each susceptible of endless variation. In fact, the more the matter is studied, the more extended the range of reactions is found to be that give rise to the formation of this substance. To show how slight an influence will lead to the production of red chloride instead of white: if freshly precipitated argentic oxide is mixed for a few moments with starch or tragacanth paste and is then treated with HCl, the result is, not white, but pink silver chloride. Even raw starch flour mixed with silver oxide will in a few moments cause it to give a pale flesh colored chloride with HCl. Boiled starch or tragacanth paste does this more quickly and acts more strongly, even in the cold, and still more if heat is applied.

Although red is probably the most characteristic color of this substance, so that I have spoken of it above as red chloride, nevertheless this hardly seems a proper name for a substance that is often purple, chocolate or black, sometimes brown or even ochreous, sometimes lavender or bluish, and is probably capable of assuming every color of the spectrum. To call it argento-argentic chloride would infer a stoichiometrical composition that as already mentioned, seems very uncertain, too much so to serve as the basis of the name. Therefore, and as these substances have been hitherto seen only in the impure form in which they are produced by the continued action of light on the normal salts, it might be convenient to call them photosalts, photochloride, photobromide, and photoiodide instead of red or colored chloride, etc., and thus to avoid the inexactness of applying the term red chloride to a substance exhibiting many other colors.

Photochloride by action of Alkaline Hypochlorites.

Black or purple black chloride is easily obtained by the action of an alkaline hypochlorite on finely divided silver such as obtained by reduction in the wet way. Commercial sodium hypochlorite may be used to act on it. It is to be poured over the silver and after standing a few minutes, is to be replaced with fresh. After an hour or two this is again to be replaced with a new portion, which is to be allowed to act half an hour to insure the total conversion of the silver. The product

varies somewhat in color, is sometimes black, oftener purple black. If the treatment with hypochlorite has been thorough, strong cold nitric acid of 1·36 sp. gr. extracts from it no silver. This reaction with nitric acid is important as it shows that not only metallic silver was not present, but that the product contained absolutely no uncombined subchloride. For if any were present it would instantly be decomposed by the acid, in which one-half of its silver would dissolve. The action therefore appears to take place in this way. First subchloride is formed, part of this is further chlorized into normal chloride which at once combines with other subchloride, thus taking it out of the further immediate action of the hypochlorite and this goes on until an equilibrium is reached and neither metallic silver nor uncombined subchloride is left, as is proved by the action of nitric acid. Alkaline hypochlorite, as will presently be shown, attacks uncombined subchloride very rapidly, the combined very slowly; by many days' contact the quantity of combined subchloride is gradually reduced.

Prolonged treatment with hot strong nitric acid destroys all the varieties of photochloride. The time needed varies a good deal. A specimen of that obtained with hypochlorite required twenty-five hours' heating with acid of 1·36 in a water-bath at 212° F. to bring it to the condition of white normal chloride. Considering that cold dilute nitric acid instantly destroys freshly precipitated argentous chloride in the free state, this long resistance to strong acid at the temperature of boiling water must be considered most remarkable.

When the red or photochloride is formed with the aid of a ferrous salt or ferrous oxide, I prefer to boil the product with dilute HCl to get rid of the last traces of iron, after a preliminary treatment with hot dilute nitric acid has removed silver and uncombined subchloride. The photochloride will sometimes even resist boiling aqua regia for a time.

Protected from light, photochloride is perfectly stable. Specimens obtained eighteen months ago appear to be quite unchanged.

When treated with ammonia, it is far more slowly attacked than the normal. The ammonia dissolves the normal chloride only. The union between the two must therefore be broken up and this takes place slowly. The first action of the ammonia is to change the red or purple color to greenish black and then to slowly dissolve out silver chloride. Hours are required even with a large excess of ammonia. Whilst this is going on, if the ammonia is poured off and replaced with nitric acid, the original color reappears. If the action is continued sufficiently long, silver only remains and dissolves readily in nitric acid. A little short of this, treatment with nitric acid

leaves a black residue of dark chloride mixed with metallic silver; the dark chloride being insoluble in any acid has led to some strange mistakes in a similar reaction which occurs in treating with ammonia silver chloride that has been exposed to the light. Even a theory has been had recourse to of a "passive condition" of silver. This passive silver is simply black chloride.

A specimen of purple black chloride was treated with warm strong aqua regia until whitened by conversion of the subchloride to normal. By this treatment 2·563 grams of photochloride gained nine milligrams, indicating the presence of 2½ per cent of subchloride, or more exactly

Subchloride	2·49
Normal chloride	97·51

This is not to be taken in any sense as representing a constant composition. The proportion of subchloride varies between certain limits, not only according to the method of preparation used but independently of it. Another specimen of black chloride formed with hypochlorite gave figures that indicated a content of less than half of one per cent of subchloride.

Photochloride by Reduction of Normal Chloride.

This is an excellent means of obtaining red chloride. The white chloride is to be dissolved in ammonia and ferrous sulphate added, producing an intensely black precipitate. After standing a minute, the mixture is to be treated with dilute sulphuric acid until it shows a strong acid reaction.

The precipitate is to be first well washed by decantation, then boiled first with dilute nitric, then after washing with dilute hydrochloric acid, which must of course be thoroughly washed out.

The product obtained in this way is often of singular beauty. It might easily be taken for metallic copper. Sometimes it is as rich and bright in color as the copper obtained by electric deposition. Everyone knows the richness and brilliancy of that form of copper and I have seen it fully equalled by this silver salt.

The beauty of the color depends always on the thorough removal of any metallic silver that may be present, and still more on getting rid of every trace of iron. The boiling with dilute hydrochloric acid should be continued until, after thorough washing, a fresh treatment extracts no more and the acid remains colorless in presence of alkaline sulphocyanide.

Instead of an ammoniacal solution of silver chloride, we may

make a solution of any other silver salt in ammonia and reduce it in the manner just described with ferrous sulphate. But in this case hydrochloric acid must be used instead of sulphuric after the reduction. This single reaction includes an almost endless variety of methods. The acid with which the silver was originally combined seems to be not without influence on the result; in some cases, for example, with arseniate and molybdate, the action of colored light on the red chloride seems to be somewhat modified. Silver phosphate on account of the ease with which it suffers reduction is very well adapted for this treatment.

Photochloride by Partial Reduction of Oxide by Heat, and Treatment with HCl.

This method has the advantage of avoiding all admixture of foreign substances, the last traces of which are very hard to get rid of, and seem to exert an effect on the color disproportionate to their quantity. Accordingly the photochloride obtained in this way is very beautiful, the shades are from pink to copper red, and a tint resembling burnt carmine.

Heat may be applied to the oxide in either of two ways, long continued heat at 212° F., or near it; or the change may be effected by roasting.

When slow heat is to be applied care must be taken that the oxide does not carbonate itself, which it easily does superficially; this is an objection because the carbonate, under these circumstances yields white chloride with which the other becomes mixed. The air of a drying oven heated by a gas burner is especially bad in this respect. I have seen a surface of oxide form a coat of yellow carbonate in a few hours in this way. (Most oxide that has been kept sometime will effervesce briskly with an acid.) The method is uncertain, sometimes giving strongly colored products and sometimes pale pink.

The oxide may be roasted in a shallow flat-bottomed porcelain basin. With a very moderate heat it changes from brown to black. When this is thoroughly accomplished and before gray reduction sets in, the oxide is to be treated with HCl. If this be done in the basin itself after cooling and without disturbing the position of the oxide, a curious variety of tints will be noticeable, depending upon slight differences in the heat affecting different portions.

Silver Carbonate may be roasted in the same way as silver oxide, and yields a similar product. By heat its color changes from yellow to black; it is probable that the carbonic acid is driven off at a lower temperature than that at which oxide is reduced to silver, and that with it escapes part of the oxygen. The residue is converted by HCl into deep red chloride.

Action of Various Metallic Oxides on Silver Oxide.

If we precipitate ferrous oxide with potash and add to this silver oxide, or what amounts to the same thing, if we add to ferrous sulphate potash in excess and pour over this silver nitrate solution, the silver oxide separated by the potash is partly reduced by the ferrous oxide, and when treated with HCl forms red chloride, the intensity of the color of which depends within certain limits on the amount of reduction of the silver oxide.

Similarly if we treat solution of manganous sulphate with excess of potash and then add silver solution, we get an analogous reaction, except that it is much weaker and heat is necessary.

With chromous oxide the action is still weaker, but evident. With cobaltous oxide it is scarcely perceptible without heat and long continued action.

Action of Ferric Chloride on Metallic Silver.

It has been long known that silver was blackened by ferric chloride, and this action has been proposed in the text books as a means of obtaining subchloride, for which it is quite unsuited.

Ferric chloride acts on silver much as sodium hypochlorite does, but less rapidly. With hypochlorite the action is complete in a few hours or often in an hour or less; with ferric chloride one or two days are required before the product ceases to yield silver to hot dilute nitric acied. In both cases the action appears to be alike in this: that no subchloride is finally left uncombined with normal chloride.

The product is an intensely dark purple black, when the action takes place in the cold. With heat continued for many hours, ferric chloride can be made to attack the purple salt and gradually convert it into AgCl. With a strong solution in large excess kept at or near 212° F. for sixty hours the color was gradually reduced to pink and finally to a dingy pinkish gray. Pure white cannot be obtained, as it can by aqua regia.

In order to observe more exactly the course of the action, a strong solution of ferric chloride was allowed to act on reduced silver in fine powder for four minutes, and then a fresh portion (always in large excess) for the same time. Analysis showed that at this stage of the action the material contained:

Ag (determined)	76·07
Cl (by difference)	23·93
	100·00

If we suppose that all the silver was combined with chlorine, the constitution of the substance would be:

$AgCl$	92·49
Ag_2Cl	7·51
	100·00

but this was probably not the case, there was almost certainly free silver present and consequently a less proportion of subchloride. Another specimen, treated repeatedly with hot acid until every trace of free silver was removed was found to contain 1·52 per cent of subchloride, color purple. Another similarly treated contained 7·3 per cent subchloride.

Action of Nitric Acid on Silver Subchloride.

When freshly precipitated and still moist subchloride of silver is treated with nitric acid, a sharp effervescence accompanied with a disengagement of red fumes, sets in; presently the strong red coloration of the photochloride appears and the action ceases. This production of the red and not the white chloride in the decomposition of Ag_2Cl is precisely what might have been expected, for when $AgCl$ is formed in the presence Ag_2Cl more or less combination always takes place.

The action is interesting in this respect: the $AgCl$ first formed is at the moment of formation in presence of all the yet undecomposed portion of Ag_2Cl, and whatever part it combines with is removed from the action of the acid. It would therefore seem probable that this method would be one of those that yielded a product having the largest proportion of Ag_2Cl, but analysis showed that different specimens were extremely variable—of those analyzed, one contained 8·62 per cent of Ag_2Cl, another 6·56, and a third 1·96. All that analysis can do with such substances is to fix the limits within which they vary. The quantity of subchloride left after treatment with nitric acid depends partly on the strength of the acid and the time for which it is allowed to act, but also to some extent on variations in the resistance of the substance itself. These specimens were of shades between rose and purple.

The color of any particular specimen is always lightened in shade by abstracting Ag_2Cl from it by continued boiling with nitric acid. But as between different specimens, especially when formed by different reactions, it by no means follows that the darkest in color contains the most subchloride.

Argentous chloride when treated with sodium hypochlorite yields a purple form of photochloride. A specimen so treated contained 2·57 per cent of Ag_2Cl.

Action of Cupric Chloride on Silver.

When metallic silver is submitted to the action of either cupric chloride, or what gives the same result, a mixture of copper sulphate and ammonium chloride, an action takes place very similar to that of ferric chloride, but more energetic, and the resulting red chloride is apt to be lighter in shade, though in this respect it varies very much. As in the case of ferric chloride this action of cupric chloride on silver is given in some text books as a means of obtaining argentous chloride for which purpose it is as little suited as the iron salt.

As a mode of obtaining red chloride it is not to be recommended. It is troublesome to get the copper completely removed.

A specimen analyzed was found to consist of white chloride with 6·28 per cent of subchloride.

Action of Protochlorides on Silver Solutions.

Cuprous Chloride.—When very dilute solution of silver nitrate is poured over cuprous chloride, a bulky black powder results which by boiling with dilute nitric acid turns red, the acid extracting little or no silver.

Ferrous Chloride.—When silver nitrate is dissolved in a slight excess of ammonia, and this solution is poured into a strong one of ferrous chloride there results a precipitate which is sometimes grayish, sometimes olive black. By washing with dilute sulphuric acid, this product becomes brownish purple, and brightens by boiling with dilute nitric acid. It was found to contain 4·26 per cent of subchloride.

Photochloride by Action of Hydrogen.

When hydrogen is passed over argentic citrate at 212° F., as in Wöhler's process, there results a black or dark brown powder consisting of argentous citrate, metallic silver, and perhaps other substances. When this is treated with hydrochloric acid and subsequently with nitric, the resulting product is photochloride, the characteristic color of which sometimes appears as soon as the HCl is added. But more frequently the material after the action of HCl has precisely the appearance of silver reduced in the wet way, and the red color appears only after treatment with nitric acid. Even cold dilute acid (by some hours' contact) will isolate the red chloride; boiling acid does so at once.

Color, beautiful purple. A specimen analyzed was found to consist of normal chloride combined with 3·11 per cent. of subchloride.

Photochloride by Action of Potash with Oxidizable Organic Substances.

There is no better method of obtaining photochloride than by acting on a salt of silver with potash and certain organic substances. Milk sugar, dextrine and aldehyde, give particularly good results. Milk sugar acts rapidly, dextrine slowly. Other substances with which, combined with potash, I have obtained chloride, are: gum, tannin, gallotannic acid, manna, glycerine, alcohol, carbolic acid. etc. The number might doubtless be indefinitely multiplied. After the action has reached a proper stage, which with milk sugar is apt to be in less than a minute and with dextrine may take half an hour, HCl is added, whereupon the precipitate changes in appearance but does not exhibit its characteristic color until after boiling with nitric acid; the best result is obtained when the precipitate, after addition of HCl, has a rich chestnut brown shade,* which by nitric acid changes to shades of purple and burnt carmine, when milk sugar, dextrine or aldehyde has been the reducing agent. When the salt of silver employed has been the chloride, of course treatment with HCl is superfluous.

A specimen obtained by acting on silver nitrate with potash and dextrine was found to contain 2·26 per cent of subchloride. Another obtained with silver nitrate, potash and milk sugar contained only 0·34 per cent. As in former instances these determinations are useful only in indicating the extreme variability of these substances and their approximate limits of composition.

Other Reactions leading to the formation of Photochloride.

A few more instances are here added, indicating the variety of ways in which this product may be obtained.

The following is an interesting reaction. If a solution of ferrous sulphate is made strongly acid with HCl and solution of silver nitrate added, the silver is thrown down as white chloride. But if to the silver solution is first added a little ammonia, enough to re-dissolve the oxide, but much less than enough to neutralize the acid added to the iron solution, then on pouring the silver solution into the iron, the silver falls as red chloride. So obtained it has at first a dull purple or shade, but by purification, as before described, a good product is obtained. This method, however, scarcely tends to the production of the splendid copper red shades of color that are got by acting on silver chloride dissolved in ammonia with fer-

* A specimen in this stage and before treatment with nitric acid was found to contain 92·68 per cent of silver, showing it to be a mixture of metallic silver with chloride and sub-chloride.

rous sulphate and then adding dilute sulphuric acid. The shade of color shown by any particular specimen is always of interest, because as before mentioned, it modifies the effect exerted upon it by the spectrum.

Potassio-ferrous oxalate.—The now well-known "oxalate developer" which I described in this Journal some years ago, throws down from silver nitrate a black powder; this precipitate treated with HCl scarcely alters in appearance, but washed and boiled with dilute nitric acid, changes to a deep purple.

Pyrogallol is capable of leading to the formation of photochloride. When ammoniacal solution of silver nitrate is poured into solution of pyrogallol in water made strongly acid with HCl, in such proportion that the mixed solutions remain strongly acid, there falls a grayish product which by washing and treatment with hot dilute nitric acid, becomes bright pink.

Ferrous oxide differs essentially in its action on silver solutions from ferrous sulphate. A silver nitrate solution added to one of ferrous sulphate, precipitates gray metallic silver. But if potash or soda is first added to the ferrous solution and then silver nitrate followed by HCl, the red chloride is formed abundantly. This reaction is similar to that already described in which an ammoniacal solution of a silver is added to one of ferrous sulphate.

To the same class of reactions belongs the following: silver carbonate with excess of sodium carbonate is thrown into solution of ferric sulphate, and after standing a few minutes HCl in excess is added. The silver is converted into red chloride.

It seemed possible that silver itself might be made the means of reducing its chloride. The experiment was made in this way: freshly precipitated and still moist chloride was intimately mixed with metallic silver in fine powder and a little water. This was heated till the water boiled and nitric acid was added. After the action was over the chloride had assumed a deep pink color. A similar result is obtained without the aid of heat, but the resulting color is much paler.

Analogous to this is the following: When a cake of fused silver chloride in a crucible is reduced with dilute sulphuric acid and zinc, if the reduction is interrupted when not quite finished, and the metallic silver is dissolved out with hot nitric acid, the residue of silver chloride will be found to be pink.

When HCl is brought into contact with Ag together with an oxidizing agent such as a bichromate or permanganate, it gives rise to formation of colored chloride. These I have not specially examined, but there can be little doubt that they are identical in nature with the foregoing. So too when silver in contact with mixed potassium chloride and chlorate is cautiously treated with dilute sulphuric acid.

The reactions above described will serve to show under what a vast variety of conditions the photosalts are formed. Most of the methods here described represent each a whole class of reactions, all resulting in the same general way, and these classes might doubtless be largely added to. Almost any silver solution brought into contact with almost any reducing agent and then treated with HCl, gives rise to the formation of photochloride. Almost any chlorizing influence brought to bear on metallic silver, has the same result. Or when silver is brought into contact with almost any oxidizing agent and HCl. It may be said without exaggeration that the number of reactions that lead to the formation of photochloride is much larger than that of those leading to production of normal chloride.

Reactions of Photochloride.

Exposed to ordinary diffuse light all the bright shades of silver photochloride quickly change to purple and purple black. The darker shades are more slowly influenced.

Mercuric chloride gradually changes it to a dirty white.

Mercuric nitrate dissolves it easily and completely, but apparently with decomposition, as it can only be recovered as white chloride.

Potassic chloride seems to be without effect.

Potassic bromide soon converts it to a dull lilac, which at the end of twelve hours, showed no further change.

In contact with potassic iodide the color instantly changes to blue gray; this change is produced by a quantity of iodide too small to dissolve even a trace of silver; the filtrate is not darkened by ammonium sulphide. With a larger quantity silver is dissolved abundantly. By acting with renewed iodide solution, the substance continually darkens and diminishes until only a few black points, barely visible, are left.

Treated with dilute solution of potassium chlorate and HCl, the red substance gradually passes to pink, to flesh color, and finally to pure white.

The action of heat on the photochloride is very curious; its tendency is generally toward redness. Specimens appearing quite black, are rendered distinctly purple or chocolate by heating to 212° F. in a drying oven. Often when the substance first separates by addition of HCl, it is pure gray; this gray will often be changed to pink by simply heating to 212°. (This happens when a gray form is produced; if the grayness is due to admixed metallic silver, it is only removed by boiling with nitric acid.)

The somewhat surprising change of color which is often seen when the crude substance is boiled with nitric acid (sometimes

from dull dark gray to crimson) is due to three concurrent actions: that of the mere heat, the removal of the silver, and the breaking up of uncombined subchloride.

It is not possible to dissolve out the normal chloride by a solvent like ammonium chloride from the photochlorides, leaving the subchloride behind. When red chloride is boiled with successive portions of strong solution of ammonium chloride in large excess, the material gradually diminishes until, if the operation is continued long enough, there remains a small residue of a warm gray color, which consists of metallic silver and dissolves without residue in nitric acid.

If sodic chloride is substituted for ammonium chloride, the same result follows, except that the operation is greatly more tedious. If persevered in until the hot solution no longer removes traces of silver chloride, the residue consists of nothing but metallic silver.

Action of Light on Normal Silver Chloride.

When silver chloride precipitated with excess of HCl is exposed to light, it becomes with time very dark. Cold, strong, nitric acid 1·36 sp. gr. extracts a trace only of silver.

The principal action of light on AgCl (precipitated in presence of excess HCl) consists in the formation of a small quantity of subchloride which enters into combination with the white chloride not acted upon, forming the photochloride, and thus is able to withstand the action of strong nitric acid. At the same time a trace is formed, either of metallic silver or of uncombined subchloride, it is impossible to say which. After a certain very moderate quantity of photochloride is formed, the action of light seems to cease. This cessation has been noted by many observers, perhaps most exactly by Dr. Spencer Newbury.

The nature of the product formed by the continued action of light on silver chloride seems to support the conclusion that the subchloride is combined with the whole of the normal chloride after the manner of lakes rather than in equivalent proportions. If the latter were the case it seems probable that the continued action of light would extend to much greater decomposition than it is found to do.

The action of light in the formation of the so-called latent image will be examined in the second part of this paper.

Photobromide and Photoiodide.

It has been already mentioned that bromine and iodine form with silver combinations in all respects analogous to those of chlorine. A more particular account of the bromine and iodine

compounds must wait for the next succeeding number of this Journal; here it can only be mentioned that these substances are formed much in the same way as the chlorine compound. They are less stable than it, and consequently the number of reactions that lead to their production is somewhat more limited. Each, however, is formed in a great variety of ways, and with the same ease as the chloride. In color they are for the most part indistinguishable from it, but exhibit different reactions.

Relations of Photochloride to Heliochromy.

The photochloride was examined both with the spectrum and under colored glass.

The rose-colored form of photochloride was that which gave the best effect. In the violet of the spectrum it assumed a pure violet color, in the blue it acquired a slate blue, in green and yellow a bleaching influence was shown, in the red it remained unchanged. The maximum effect was about the line F, with another maximum at the end of the visible violet, less marked than the one at F.

Under colored glass the colors obtained were brighter; under two thicknesses of dark ruby glass, the red became brighter and richer. Under blue glass some specimens gave a fair blue, others merely gray. Under cobalt a deep blue was easily obtained, and under manganese violet, a fine violet, very distinct in shade from the cobalt. Green produced but little effect—yellow was sometimes faintly reproduced but rarely. But the yellow glass of commerce, even the dark yellow, lets through portions of nearly the whole spectrum, as can readily be seen by testing it with the spectroscope.

The dark purple forms of chloride do not give as good results as the rose and coppery shades. These last have many points of resemblance with the material of Becquerel's films, resemblance of color, probably of composition, as far as we can judge of the constitution of those films from their origin; they were far too attenuated to admit of analysis; and resemblance in the curious way in which their color is affected by heat, so that the conclusion seems inevitable, that they are at least closely related.

There is certainly here a great and most interesting field for experiment; hardly any two specimens of photochloride give exactly the same results with colored light, and this suggests great possibilities. There is the very great advantage in this method over any previous, that the material is easily obtained in any desired quantity and in a condition most favorable for experiment.

The action of light on photochloride can be a good deal affected by placing other substances in contact with it. Any substance capable of giving up chlorine seems to influence the action somewhat; ferric chloride often acts favorably, also stannic and cupric chlorides.

Evidently an important point in all heliochromic processes is that as white light must be represented by white in the image, it is an essential condition that white light must exert a bleaching action on the sensitive substance employed. Red chloride does not bleach but darkens in white light, but the property of bleaching, to a very considerable extent, may be conferred on it by certain other chlorides, and particularly by lead chloride and zinc chloride.

This I look upon as very important.

Another matter of interest is exaltation of sensitiveness, and this I find is accomplished in quite a remarkable way by sodium salicylate, the presence of which at least trebles the the action of light on these substances. And probably on others.

I am persuaded that in the reactions which have been here described, lies the future of heliochromy, and that in some form or other this beautiful red chloride is destined to lead eventually to the reproduction of natural colors.

Philadelphia, March 23, 1887.

ART. XXXVII.—*On the Inter-Relation of Contemporaneous Fossil Faunas and Floras;* by CHARLES A. WHITE.

IT is apparent to every paleontologist who aims at a comprehensive knowledge of his subject that the idea which has heretofore prevailed, that for every epoch or period of geological time certain characteristics have been so impressed upon every class of animals and plants which then existed that their remains, if properly investigated, will be found to bear intrinsic evidence as to the particular epoch in which they respectively lived, must be accepted with a good degree of qualification. We ought naturally to expect to find that the rate of progress of evolutional differentiation from epoch to epoch has been variable, when comparisons are made between marine faunas on the one hand and continental faunas and floras on the other, because the conditions under which they respectively lived are so different; but it is scarcely less apparent that such differences have often been very great among the different classes which contemporaneous continental faunas and floras have embraced. In a former publication for example* I have shown that dino-

* See this Journal, III, xxvi, pp. 120–123.

saurian remains of Cretaceous types, molluscan remains of both Tertiary and living types, and plant remains of both Tertiary and living species, have been found in such intimate association in strata of the Laramie Group as to indicate that they all lived contemporaneously. In another publication* I have shown that remains of living species of land mollusks have been found associated in the same strata with those of extinct genera and families of Miocene vertebrates. In still another,† I have shown that a fresh-water mulluscan fauna, nearly all the known species of which are closely related to living forms, has been found in Jurassic strata associated with a great variety of dinosaurian remains.

The following remarks in support of the opinion just advanced have reference to other cases which have been observed in connection with the great series of intra-continental strata which is found occupying a large region in the western part of our national domain; the vertical range of the series being from the Laramie Group to the Bridger, the uppermost of the fresh water Eocene Groups, inclusive.‡ This series is one of unusual interest because of its intra-continental origin, of its great thickness and geographical extent for a series of such an origin, and of the importance of the fossil remains which have been collected from it. Indeed a large part of our present knowledge of the extinct land vertebrate life of North America has been derived from this series of strata; and yet that knowledge is strikingly imperfect and fragmentary. It is of course not strange that any record of extinct vertebrate life should be imperfect, but the broken character of this one is the more noteworthy because the record of both the invertebrate and plant life for the same series of strata and within the same region, seems to have never been wholly broken. Besides this evidence of the continuity of invertebrate and plant life in the series referred to, studies which I have prosecuted in the field, and also among the collections which have from time to time been obtained from those formations, have disclosed satisfactory proof that for the whole series there was continuous sedimentation within a large area.§ How large that area was has not been determined, but it is known to have embraced a considerable part of central and northern Utah.

It is probable also that in northeastern Montana and the adjacent part of Dakota, sedimentation was continuous from

* Bull. U. S. Geol. Survey, No. 18, pp. 10–16.

† Bull. U. S. Geol. Survey, No. 29.

‡ For a tabular exposition of the principal formations of the Rocky Mountain region, showing the relations of this series to other formations, see Ann. Report U. S. Geol. Surv. Terr. for 1876, p. 22.

§ See Bull. U. S. Geol. Survey, No. 34.

the Laramie up into the equivalent of the Wasatch, and perhaps also into that of the Green River Group.*

This result of those studies makes it necessary to deny the correctness of the claim, which certain authors have made, that there was an entire stratigraphical break in the series referred to at the close of the Laramie period. Still, it is not denied that the Wasatch strata usually, if not always, rests unconformably, if at all, upon the strata which have been called the Bear River Laramie; and in some cases also upon other Laramie strata. In short it is admitted that the area of continuous sedimentation was materially restricted at the close of the Laramie period; but it was not wholly interrupted until the close of the Bridger epoch.

Besides the recognition of proof that sedimentation was continuous through the whole vertical range of this intra-continental series of deposits within at least certain portions of the area they occupy, the studies referred to have resulted in showing that certain of the species of the fresh-water gill-bearing mollusca of the Laramie period survived into the Wasatch epoch and became an integral part of the then existing purely fresh-water molluscan fauna.† Furthermore, it is well known that certain other molluscan species range through the whole fresh-water Eocene series, from the Wasatch to the Bridger Group, inclusive. Again, Professor Lester F. Ward has shown that more than twenty species of plants are common to the Laramie and Green River Groups; thus indicating that a large proportion of the species of the Laramie flora long survived the close of the Laramie period and mingled with the floras of the succeeding epochs.‡

Here then, we have what is regarded as satisfactory proof that the stratigraphical series is complete from the Laramie to the Bridger Group, inclusive. And yet within the vertical range of that series the remains of several distinct land vertebrate faunas are found, which are not only widely diverse in their characteristics, but seem to have been introduced and extinguished with a suddenness that has left us with little or nothing learned concerning either their ancestry or their progeny. Indeed, a considerable proportion of the fossil vertebrate faunas which have been discovered in the North American Mesozoic and Cenozoic strata are so clearly defined from one another by their own distinguishing characteristics that they appear to have been suddenly introduced and as suddenly extinguished. Moreover the differences in the characteristics

* See Bull. U. S. Geol. Survey No. 34, pp. 16, 17; also this Journal, III, xxv, pp. 411–413.

† Bull. U. S. Geol. Survey, No. 34.

‡ Sixth Ann. Report Director U. S. Geol. Survey; table covering pp. 443–514.

of these faunas is very great, even when they are found to occupy stratigraphical horizons so closely approximating each other as to indicate that they were not separated by any considerable interval of time. This condition of things is sufficiently perplexing from a purely zoological point of view, but it assumes an additionally serious aspect when these sudden appearances and disappearances of peculiar faunas are used as indices of the exact limits of geological epochs.

While it is clear that many faunas may have been rapidly extinguished by sudden changes in their environment, we cannot admit that any have been introduced into a given area with anything like the suddenness that is indicated for certain of the faunas presently to be mentioned, except by some physical change that should cause the enlargement of the area previously occupied by such a fauna, or its transference from one region to another. That is, it is assumed that in case a distinct fauna has been suddenly introduced into any given region, it has been by transference from some other region which it had previously occupied, and where its evolution had been accomplished.

The first of the vertebrate fauna which I shall mention in this connection is that of the Dinosauria of the Laramie Group. This is the latest dinosaurian fauna which is known to have existed upon the North American continent, and it is probably the very latest that existed upon the earth. Its remains are comparatively rare, although large and characteristic forms existed until the close of the Laramie period. These dinosaurian remains are the only fossils yet found in the Laramie Group upon which has been based the claim that it is of Cretaceous age; and the character of the plant and invertebrate remains in the same formation is such that but for the presence of the dinosaurs no one would have thought of referring it to any Mesozoic period. The few remains of dinosaurs that have been found in the Laramie Group range up to its uppermost strata, and the extinction of those forms seems to have been simultaneous with that of the brackish water mollusca whose remains characterize the Laramie Group, so far as its invertebrate fauna is concerned.

Professor Cope has published an important mammalian fauna from certain strata in New Mexico, which he designates as the Puerco Group, the position of which is between characteristic Laramie strata beneath, and equally characteristic Wasatch strata above. These Puerco strata were originally referred to the Wasatch Group and, as they are also of fresh water origin, and not widely different in lithological character from those of the Wasatch, which rest conformably upon them, it is not probable that any other designation would have been given

them if they had not been found to contain the vertebrate remains in question.* According to Professor Cope this Puerco fauna is, as a whole, quite unlike any vertebrate fauna that is now known to have either preceded or followed it upon this continent; although certain of its types are related to some that are found in the Laramie and Wasatch Groups respectively. Still, in consequence of the presence of certain types which he regards as Mesozoic, Professor Cope thinks the fauna possesses more of a Cretaceous, than of a Tertiary character. The lowest strata in which the remains of this fauna have yet been found closely coincide in position with the top of the Laramie Group; and they disappear suddenly upon a certain higher horizon which seems to come within the basal portion of the Wasatch Group. Moreover, the known area within which this Puerco fauna has been found is only a small part of that within which the Laramie and Wasatch groups occur. That is, the Puerco fauna has not been recognized at the majority of the localities where the Wasatch has been found overlying the Laramie. In some of the latter cases the two formations have been found to be closely connected, not only by strict conformity of the strata, but also by an intermingling of their molluscan faunas; and in none of them has any indication of a missing formation been observed.

The next vertebrate fauna to be considered is that of the Wasatch Group, which is a remarkable one for its abundant variety and diversity of forms. All persons who have studied this fauna agree in regarding it as of Eocene age, including as it does Coryphodont and other distinctly Eocene types. With this reference the plant and vertebrate forms agree, except that some of the former have been regarded as of later Tertiary types. The Coryphodont and other Eocene vertebrate remains referred to have been found in the lowermost of the Wasatch strata as well as at higher horizons in the group, and, as before said, some of the Laramie dinosaurs have been found in the uppermost strata of the latter group.

Above the Wasatch Group proper, the Coryphodonts soon disappear, and other changes in the Eocene vertebrate fauna gradually take place up to the close of the Bridger Group. Above the Bridger Group the vertical continuity of the intra-continental Tertiary deposits of that western region is broken. That is, the later fresh-water Tertiary deposits were formed in isolated basins, and they therefore do not constitute part of a continuous series, with that of the preceding deposits. Consequently the geological age of those later deposits must be determined by means of their fossil contents alone, without the

* For a concise account of the Puerco by Professor Cope, see Am. Naturalist, xix, p. 985. See also same volume, pp. 385 and 493.

aid of known stratigraphical continuity. As my present object is to discuss certain of the faunas of the preceding formations with relation to the order in which the latter were deposited, those later Tertiary deposits will not be further considered on this occasion.

What we now know of the order of succession of the vertebrate faunas which have inhabited that western region, so far as that knowledge is necessary to the present discussion, may be briefly summed up as follows: Dinosaurian life continued until the close of the Laramie period and then suddenly ceased. The Puerco mammalian fauna was suddenly introduced within the limited area where its remains have been found, and as suddenly extinguished there about the close of the Laramie period or the beginning of the Wasatch. The Wasatch mammalian fauna was suddenly introduced in the region under discussion at the close of the Laramie period and coincident, or nearly so, with the extinction of the dinosaurs or, at latest, with that of the Puerco mammals.

The dinosaurs of the Laramie period were evidently not materially different in general character from those of the preceding periods; and there is no reason to doubt that they were direct descendants of the latter. They found a congenial habitat upon the borders of a great inland sea in the deposits of which their remains are found, and until the Puerco mammalian fauna was introduced into a part of the region which they occupied. They also appear to have continued their existence in at least certain parts of their former habitat after the introduction of the Puerco fauna, and until the introduction of the Wasatch mammalian fauna into the same region. We have no positive evidence that the Laramie dinosaurs continued their existence in direct association with either the Puerco or Wasatch mammalian faunas, because no Dinosaurian remains have been found associated with those of either of the faunas named. The probabilities are that the dinosaurs met their extinction in the struggle for existence which ensued upon the introduction of one or both the mammalian faunas just mentioned.

Now it seems necessary to infer that these changes in the character and continuity of vertebrate life were mainly due to important changes which from time to time took place in the physical conditions of the continent. And yet it is evident that those physical changes were not sufficient to interrupt the continuity of either the invertebrate or plant life in the same region, nor to wholly interrupt the continuity of sedimentation in the intra-continental waters. In short it is quite evident that the land vertebrate life of North America has been subject to certain influences which effected great changes in, and

no doubt caused many extinctions as well as dispersions of its faunas, but which produced little or no effect upon at least a considerable part of the contemporaneous plant and invertebrate life. Concerning the nature of those changes which thus affected vertebrate life our present knowledge is quite limited, and much is therefore left to conjecture. The suddenness, however, with which the remains of land vertebrates have successively appeared within a great unbroken series of intra-continental strata seems to make it necessary to conclude that one of the results of those changes was the removal from time to time of certain physical barriers which previously restricted the dispersion of those faunas respectively.

I have already given my reasons for believing that the sedimentation of that great series of strata, from the Laramie to the Bridger Group inclusive, was at no time everywhere entirely interrupted, and that there was for the whole time, and within the region where that series was deposited, an unbroken continuity of invertebrate and plant life. If these conditions actually existed we must necessarily conclude that the Puerco and Wasatch mammalian faunas were both suddenly and independently introduced into the region where they are now found, from some other region where they previously existed.

This view of the case shows the impropriety of regarding the earliest strata in which the remains of a certain fauna happen to be found as indicating the exact time of the ushering in of the epoch to which that fauna is assumed to belong. For example, it is claimed by those who have studied the vertebrate faunas of the Puerco and Laramie groups that they ought to be referred to the Cretaceous period; and they are equally positive that the Wasatch Group should be referred to the Eocene. Now the dinosaurian remains of the Laramie are known to range up to the uppermost strata of that group; and many of those of the Coryphodonts and other Eocene mammals have been found in the lowermost strata of the Wasatch. So closely do these two fossiliferous horizons come together, and so evident is it that sedimentation was continuous from the one to the other, we cannot assume that any considerable time elapsed between the deposition of the latest strata of the one group and that of the earliest strata of the other, notwithstanding the intervention of the Puerco fauna in a part of the region where both the Wasatch and Laramie Groups are found.

Here then, we find the remains of Cretaceous dinosaurs, of a unique mammalian fauna, and of a distinctively Eocene mammalian fauna, all in an unbroken series of deposits, each occupying separate horizons which so closely approximate each other that it is evident sufficient time did not elapse during the deposition of that portion of the stratigraphical series to have

allowed the successive evolution of the faunas in question. We must therefore assume that at least the Puerco and Wasatch mammalia were developed somewhere else, and that they were respectively transferred to the region in which their remains are now found.

The Puerco fauna is so unique in character that, with our present limited knowledge of it, and our present methods of paleontological study, it appears to mark an epoch in the history of vertebrate life of North America of which the invertebrate and plant remains, and the stratigraphical condition of the series of deposits in which they occur, give no indication.

At present also we know nothing of the immediate ancestry of the Wasatch mammalian fauna, but in view of its highly developed, diversified and distinctive character, we must conclude that it existed somewhere, possessing essentially the same characteristics which its known remains now exhibit, long before the earliest Wasatch strata were deposited. The stratigraphical conditions before referred to indicate so short a time for the deposition of the strata within the vertical range of which the remains of these three faunas are found, that it also seems necessary to conclude that the Wasatch fauna existed somewhere contemporaneously with the Puerco mammalia from which it differs so much, and also contemporaneously with the Laramie dinosaurs, from which it differs far more widely. The conclusion therefore seems to be irresistible that the faunal types which are regarded as diagnostic of the Eocene period existed contemporaneously with those which are equally diagnostic of the Cretaceous period.

That faunas and floras of Cretaceous and Tertiary types should have existed contemporaneously is not strange, for a similar diversity now exists as regards the living faunas and floras of different parts of the world; and they have doubtless existed in a greater or less degree ever since animals and plants came to be widely differentiated. It is strange, however, that this latter fact should be so often ignored in discussions of the relative ages of extinct faunas and floras.

The foregoing remarks are confined mainly to cases in which continental faunas and floras are compared with each other, and with reference to the usually accepted paleontological standard. The following remarks are made with reference to the fossil faunas and floras of the great intra-continental deposits of North America, as compared with those of presumably contemporaneous sea coast deposits. Ever since the publication of my views as to the inland character of the sea in which the strata of the Laramie Group were deposited, they seem to have been accepted without serious question; and the purely fresh-water character of the deposits which succeeded

the Laramie, admits of no doubt as to their lacustrine origin. I have therefore referred to these as intra-continental deposits, and to the remains which they bear as those of continental faunas and floras, as contrasted with marine faunas. The term sea coast deposits is used in contrast with the forementioned term which is applied to the other deposits, and by it is of course meant the well known marine strata, the order of superposition of which can be more or less satisfactorily traced from the earlier to the later geological epochs.

Because of the isolation of the intra-continental deposits they can have no place in any observed order of superposition among marine deposits, and for this reason they must therefore be studied separately. The great difference also between the aqueous faunas of the fresh and brackish waters respectively in which the former deposits were made, and those of marine waters, makes a chronological comparison of the two categories of deposits, by such means, a matter of great uncertainty. This is an additional reason for their separate study until satisfactory data can be obtained for their correlation with marine formations. While I believe that such correlation, if ever effected, must be based mainly upon paleontological data, we ought to expect much aid from lithology and physical geology, especially when studied in connection with paleontology.

Pursuing a consideration of the latter subject we may reasonably infer that certain species among the land faunas and floras have occupied the region between any given inland sea or lake on the one hand, and the open sea on the other, across the whole intervening region, unless there were known physical obstacles to such dispersion. Therefore the remains of such species might easily occur in both inland and coast deposits. That is, remains of the same species of land animals and plants may have been entombed in lacustrine deposits on the one hand and estuary deposits along the sea coast on the other, the species having occupied the whole of the intervening land area. The contemporaneity of such deposits would be thereby apparent; and in my estimation such evidence would be more conclusive than any other.

Still, as a matter of fact, no correlations of intra-continental, with sea coast deposits of North America have yet been accomplished either by such means, or by any other practical method. It is nevertheless true that most of the authors who have written upon the formations in question have referred both the inland and sea coast series to respective subdivisions of the geological scale which was originally established for Europe, and supposed to be of universal application, with a confidence which is only warranted by positive knowledge. For example,

certain deposits along our sea coasts are referred with confidence by most paleontologists to the Eocene, Miocene and Pliocene epochs respectively, as those epochs are recognized among European formations. Certain of our great intra-continental deposits are also referred to those three epochs with equal confidence; and yet no direct paleontological proof has been adduced that any one deposit of either of these two North American series was, even approximately, contemporaneous with any one of the other series. By direct proof I of course mean that which is furnished by specific identification of fossil remains or derived from well comprehended phenomena of physical changes, as contrasted with theoretical inferences derived from a foreign standard, and assumed to be of rigid application here. Still, in view of the reasonable hope that great discoveries of fossil continental faunas and floras are yet to be made, and much concerning the physical geology of the continent is yet to be learned, we ought not to despair of obtaining some of the direct proof which is so desirable. An encouraging fact in this direction is the one lately pointed out by Professor Ward that four of the species of plants which occur in the Laramie Group occur also in the Lignitic deposits of the marine Tertiary series of the Gulf States;* and when the fossil floras of the continent are thoroughly known, much more information of this kind may be expected from them.

Now in case the specific identifications referred to should be made, and the contemporaneity of the formations be thereby proved, what effect ought that circumstance to have upon the nomenclature of formations already recognized and named? For example, the Laramie formation was deposited in a great brackish-water inland sea, and it contains a characteristic aqueous fauna which is distinct from that of any other known formation. Other deposits were of course simultaneously formed along the sea coasts, and perhaps upon other parts of the continent also, all of which contain remains of faunas that, so far as known, differ materially from those of the Laramie, and also from each other. Among those which probably contain a flora similar to that of the Laramie are the Eocene Lignitic of the Gulf States, and certain deposits upon the Pacific Coast in Washington Territory, which have been investigated to some extent by Professor Newberry. Among the marine formations which were deposited simultaneously with the Laramie, is almost certainly a part of the Chico-Tejon series of California.

In view of the extent and importance of the intra-continental deposits of North America, and the radical differences of their fossil remains from those of the marine formations, it is plain

* Sixth Ann. Report Director U. S. Geol. Survey, p. 529.

that we must range the formations of this continent under two separate categories, the nomenclature of each of which should be kept distinct, even after their contemporaneity may have been ascertained. Furthermore, correlations between the two categories should be based primarily upon phenomena observed or observable upon this continent, for it is now evident that no foreign standard will be found adequate for this purpose.

ART. XXXVIII.—*The Eozoonal Rock of Manhattan Island;* by L. P. GRATACAP.

A BED of serpentine rock bordering the western margin of New York Island between 55th street and 60th street, and now for the most part built over, some years ago awakened a momentary interest from its display of strips of ophio-calcite which resembled the eozoonal beds of Canada, and led to some surmises as to their organic character. This area of serpentinous rock, forming a band enclosed on the west and east by mica schists or a highly micaceous gneiss and limited southward by a broad outcropping of granite, is gradually disappearing from view and may at any time become an affair of local record. At present its best exposure is on the north side of 59th street between 10th and 11th avenues, and it can be traced to near 56th street, by isolated knobs appearing above the level of the sidewalk and in back yards. It was recently uncovered to some extent when the cisterns for the immense gas-holders of Equitable Gaslight Company were being constructed, and some examinations then made both of the rock in place and of microscopic sections, may prove of interest in view of the general attention given to the discussion of the origin of serpentine, a discussion which seems to widen; and to which the later contributions by Dr. Becker* would seem to give a new impetus.

This outcropping of serpentine is intimately associated with and intermingles with an acicular fibrous partially altered hornblende or actinolite, the hydrous anthophyllite of Dana. From this area were derived the numerous bowlders of this rock which are found to the south as far as the northern margins of Long Island. Dr. L. D. Gale, as quoted by Mather,† describes this anthophyllite locality in the following words: "This rock extends from 59th street following the strike, which is N. 30° E.; varies from this to due north and south as far as 63d street, where it dips down and disappears below the river.

* Cretaceous Metamorphic Rocks of California, by G. F. Becker, this Journal, xxxi, p. 348.

† Geological Survey of New York, Pt. 4, p. 581.

The rock varies considerably in character in different places where it has been uncovered, and occupies a series of conical hills some five or six in number, distributed in a northerly and southerly direction. In some places, as at 60th street, it is talcose in structure, and may be split into thin slabs; in others it is dark gray, almost black, composed of straight fibers arranged in a columnar form, meeting and crossing each other frequently at right angles." He further says, "it is remarkable that the granite lying on the west and the gneiss on the east of the rock in question, come in complete contact with it without intermixing. So remarkable is the line of separation on the side next to the gneiss, where there is the best opportunity to examine the two, that within the space of three inches, each rock possesses all of its own peculiarities, with none of those of its neighbor." In speaking of the serpentine, he says, "in the same vicinity are found masses of serpentine and limestone intermixed exhibiting a porphyritic appearance, the serpentine appearing green and the limestone white;" this refers to the eozoonal-like portions which would seem, so far as their microscopic appearance goes, to easily warrant their reference to a close relationship with the Canadian rock containing that debateable organism.

Cozzens, in his Geological History of Manhattan or New York Island (1843), p. 12, refers to this locality, saying, "between 54th and 62d streets, the shore and 10th avenue, there are four or more small knolls of black serpentine, with scales of silvery or golden talc, accompanied by a vein of anthophyllite about twelve feet wide. This vein is in a vertical position. At the north end of the serpentine proper, this anthophyllite shows itself in two places, *in place;* one, on the rising ground, and near the sienite, the other at high-water mark on the shore. Actinolite is found imbedded in the anthophyllite. The serpentine locality commences where the granite ends. At the south end there is a vein of carbonate of lime. This carbonate of lime has many small specks of serpentine diffused through it, and forms a kind of 'verd antique,' which, when polished, makes handsome specimens."

These early observers speak of the association of the serpentine with hydrous anthophyllite, and this association points significantly to the origin of the serpentine itself. This bed of serpentine is in all probability an altered amphibole or hornblende schist and the "porphyritic," "verde antique," eozoonal portions, the products of such, are alterations produced under conditions of strain and pressure, accompanied by aqueous infiltrations. I have not seen the vein of anthophyllite alluded to above, but on visiting the locality on 59th street, where a ledge rises up in a mound-like prominence, I found

anthophyllite in masses, apparently recently blasted and removed from their beds of place, with which was seen actinolite largely serpentinized. An examination of the hill showed a vertical face where Eozoon structure (ophio-calcite) was seen at a number of points. It appeared in seam-like bands, expanding in some places and contracting at others, forming an irregular scattered prolongation of parts, varying in grain from fine to coarse, the former accompanying an apparent flexure or contortion of the original stratum. On the south side of 59th street, where the excavations were being made, mentioned above, an exposure of the serpentine bed was accessible where the ophio-calcite was seen, frequently presenting a seam-like appearance, contracting to narrow bands and again developed in broader sections, while sometimes it sporadically occupied nests or spots enclosed in the surrounding rock. Away from these parts the serpentine was fibrous or micaceous.

Should any one feel disposed to refer these eozoonal-like portions (fig. 7) to an organic origin, the extended irregular

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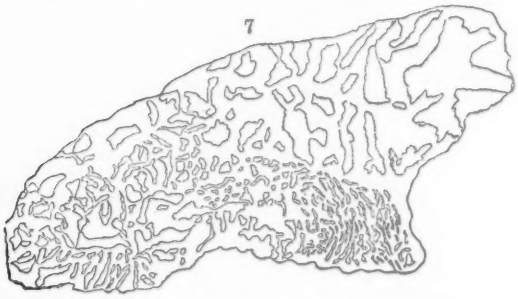


vein-like parallel strips, which they present, would form a seemingly strong objection to such a reference. Coralline bodies occur in reefs or reef-like lines, but this mosaic of serpentine and calcite has nothing coralline about it in any sense, and when placed, as it only can be placed, on the assumption of its zoological affinities, with the protozoa or metazoa, it repels all analogies with any thing in those classes of animal life, by its linear extent, the actual length of these broken strings of ophio-calcite, being in the exposed sections, from 10 to 20 feet.*

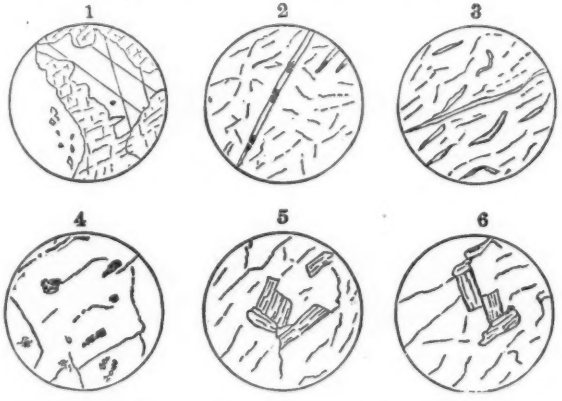
The films of this "verde antique" are not horizontal, but

* It is true that Professor Hyatt (Science, vol. vi, p. 386) speaks of spongoid bodies *Archæocyathus*, *Ethmophyllum*, etc., as probably the reef-builders of the primordial seas, so that linear extent merely might not preclude the possibility of the eozoonal rock being referred to an organic origin. But when in connection with their length these eozoonal veins have only a moderate width of a few inches their reference to the reef-like masses of sponges seems incredible.

rise and fall as if they had undergone plication, but so strongly do they suggest the quartz or granite veins found in the folded gneiss layers of the island, that their origin may be connected with this very plication, the incipient change in the original hornblende schist having been induced at the moment of folding, the alteration involving the change of the hornblende to serpentine, with the exclusion of lime, which through the action of percolating waters finally filled the interstitial spaces as calcite.

An examination of the thin microscope slides, made of sections of this ophio-calcite, proved very satisfactorily the change of the hornblende into serpentine, threw some light upon the process of change, and lent some support to the view of the segregated character of the calcite.

Groups of hornblende crystals were constantly encountered surrounded by the serpentine (figs. 5, 6), while in these, phases



of alteration were detected and separated. The change of the hornblende to serpentine seemed to be frequently preceded by a breaking up of the hornblende into fibers, giving the blade a striated appearance, while the serpentine granules develop along these. In some cases the hornblende blade is replaced in patches by serpentine, against which the remaining fibrous substance, partially changed, but not deprived of its acicular appearance, abuts with a crenulated margin. A second method of change seems to consist in a sort of exfoliation, the hornblende stripping up, the alteration entering from all sides with no apparent physical change, to the condition of asbestus. In this second process the hornblende presents an eroded appearance and frequently shows minute cavities, the whole aspect being not dissimilar to that of a melting fragment or

pellicle of ice. In one instance a section displayed a pavement of hornblende enclosing a strip of serpentine with a plentiful sprinkling of magnetite, and in another example, an interesting illustration of the change of the hornblende to serpentine, was observed where a long fiber of the actinolite (?) was altered to serpentine at nearly equal lengths throughout its extent. The alteration started from minute transverse breaks and progressed on either side for a short distance into the substance of the crystal. The unchanged portions of the amphibole separating these serpentinized joints, gave the fragment the appearance of an equisetum (fig. 2). This was repeated less strikingly in the same section over its entire surface. Again aggregates of viridite or chlorite were seen scattered over the serpentine in one slide (fig. 4), a possible phase in the change of the hornblende to serpentine or a secondary product of its alteration.

The formation of the calcite in an interrupted manner seemed clearly shown in many instances, as where two irregularly interlocked areas of this mineral were seen with the cleavage lines of one section abruptly terminating at the margin of the other (fig. 1). This would lead to the inference that the deposition of the two parts was not simultaneous and lend support to the view of the intermittent secretion of the calcite from aqueous solutions, in the interstices of the serpentinized hornblende. Lacunæ of calcite appear irregularly through the serpentine, the ragged and spiculate edges of the serpentine yielding inwards, while in some instances a semi-dark line marking a change of thickness, separated an interior core of calcite from the border contiguous with the serpentine, an indication of intermittent secretion.

The examination of these sections leaves little room for doubt that a bed of hornblende rock has undergone a conversion more or less complete into serpentine, and that along lines of strain incident to its folding, where thermal conditions of an intense character were developed, accompanied, or perhaps succeeded by the introduction of water, the change has been perfected most rapidly and has been assisted by the elimination of lime carbonate as calcite, and probably in some cases the double carbonate of lime and magnesia as dolomite.

ART. XXXIX.—*Terminal Moraines in Maine;* by GEORGE H. STONE.

ONE of the most obvious features of the glacial drift of Maine is its unequal distribution. Many of the multiform ridges and heaps of till which abound in the State may par-

take of the nature of medial and terminal moraines. In classifying these deposits it will be needful to distinguish accumulations of till which were formed beneath or within the ice-sheet from superficial accumulations which were the result of the local movements sure to occur during the unequal melting of the retreating glacier. We know so little as to the nature of the work going on in the lower portion of an ice-sheet that this distinction is a difficult one to make. Omitting a great number of doubtful cases, there are a few places in the State where the till is piled in narrow ridges which lie transverse to the direction of glaciation and which so clearly have the form and composition of terminal moraines that they must be regarded as having been formed at the end of a moving mass of ice. In some cases kames also appear to have been deposited at the ice-front and thus were practically a part of the terminal moraine, but they are omitted from this list. So far as I know the following list includes all of these formations in the State concerning which the evidence is reasonably conclusive.

1. *The moraines of the local Androscoggin Glacier.*—After the great ice-sheet was so far melted that the general movement ceased, there was still for a time sufficient ice in the White Mountain region to cause a glacier to flow eastward along the valley of the Androscoggin River, as far as West Bethel, Maine. This local glaciation was first described by Professor G. L. Vose and Professor A. S. Packard in the first and second volumes of the American Naturalist, afterwards by Professor C. H. Hitchcock in the N. H. Geological Reports; and briefly by the writer in the American Naturalist for April, 1880. The most remarkable terminal moraine of this glacier is at the great bend of the Androscoggin near the boundary between Shelburne, N. H., and Gilead, Me. No one who sees this can hesitate to regard it as a true terminal moraine of a local valley glacier.

2. *At Readfield Village.*—In the western part of Readfield village (near the woolen mill) is a confused series of hummocks and short ridges extending from north to south across the valley of the small stream on which the mills are situated. From this point the valley continues nearly west for about one mile when it turns northward and soon widens into a valley which resembles a mountain cirque. This wider valley apparently was filled with ice which flowed down the narrow valley to Readfield village. At several places along the valley are masses closely resembling lateral and semi-terminal moraines. At the woolen mill the valley proper is only about one-eighth of a mile wide. The morainal hummocks are chiefly made up of till which is somewhat coarser and more sandy than the ordinary till of the region, as if slightly water-washed. In a

few places along the roads the deeper cuts show masses of stratified sand and gravel underneath unstratified till, and these sediments are in some cases plainly cross-bedded. There are no signs of a land-slide here, indeed the slopes of the neighboring hills are too gentle for that. Are these hummocks the work of the great ice-sheet or of a local glacier? There are in Maine very many deep sheets and ridges of till left by the ice-sheet across east and west valleys, but these hummocks in question are a different kind of ridge from the gently sloped ridge of ice-sheet construction. If these small and steep masses are remains of a broad sheet of till irregularly eroded, then in the depressions between the hillocks there ought to be found an abundance of the larger stones and bowlders of the till, such as are found in the present bed of the stream.

About one-third of a mile east of this point and at nearly the same elevation above the sea (215 to 230 feet), there is at the Fair Ground a terrace of stratified sand and silty clay. No fossils have been found in these beds, but at Winthrop Village and at an elevation only a few feet less, marine shells are common in sedimentary clay. It thus appears that in Champlain time the sea extended from the Kennebec Bay of that period westward to Winthrop. But Winthrop and Readfield are at opposite ends of Lake Maranocook and if the sea extended to Winthrop it would necessarily reach to Readfield unless kept back by a barrier of ice. Probably the sedimentary beds at and near the Fair Ground, Readfield, were Champlain shore deposits and the hummocks of mixed till and sediments in the western part of the village were formed where the local valley glacier confronted the narrow arm of the sea.

3. *The Swan Island Moraine.*—Swan Island is an island in the Kennebec River. It begins near Richmond and extends for about four miles southward. About one and one-fourth miles from the southern end and on the eastern side of the island is an east and west ridge about one-fourth mile long that is probably a terminal moraine. It appears to have suffered considerable surface erosion by the Champlain sea. A short kame is found near the western end of this ridge. The marine clays cover the flanks of both kame and moraine so as to disguise their relations to each other.

4. *The Sabattisville Moraine.*—A short distance south of the bridge at Sabattisville is a two-sided ridge of till which extends for a little more than one-eighth of a mile across the valley of the Sabattis stream. The ridge rises from eight to fifteen feet above the plain of marine clay and is composed of quite sandy till, as if gently water-washed. The steepness of the ridge on both sides and its east and west direction mark it as a terminal moraine. The ridge is partly within the village,

and considerable of it has been removed within the past few years.

5. *The Machias Moraine.*—This is situated about five miles south of Machias village, near the first fork of the road found in going in that direction. It extends from Englishman's River northeastward for about three-fourths of a mile to near an arm of the sea. It is interrupted for a few rods by a swamp and a small hill and then begins again. The part most clearly a terminal moraine lies west of the road leading south from Machias. It is a ridge which rises rather steeply on each side to a height of from fifteen to twenty-five feet above the plain of marine clay in which it is situated. At one place the deposit is wider and is double, the two ridges being separated by a shallow depression which is not, however, a kettle-hole. The southern slope of the ridge shows many bowlders from one to four feet in diameter, while just beyond the crest on the northern slope are several feet of stratified sand, gravel and pebbles. This probably was the result of the Champlain surf which broke on the southern slope and washed the finer drift over the ridge beyond the reach of the undertow and left it stratified on the northern slope. At least the western portion of this formation must be a terminal moraine, though somewhat different from some of the others here described.

6. *The Waldoboro Moraine.*—This is somewhat more than five miles long, with a few short gaps.

On the west this moraine appears to begin a short distance west of Winslow's Mills, a way station of the Knox and Lincoln railroad, situated about three miles northwest of the village of Waldoboro. These mills are on the Medomac River, a stream about twenty-five miles long, which empties into the sea at Waldoboro. For several miles north of Winslow's the Medomac has been flowing nearly south through a gently rolling plain, but near the mills the valley is encroached upon by a hill which here rises on the eastern side of the stream to a height of about 200 feet above the sea. This hill slopes northward and within a mile sinks to a level with the Medomac. On the west of the stream there is a moderately steep slope, but the hill is not so high as that on the east side of the valley. The moraine appears to begin on the slopes of this hill about one-fourth of a mile west of the Medomac and at an elevation of about seventy feet above the stream. There are here three nearly parallel ridges, the most southern one being only a few rods long and eight to ten feet high. The steepness of the slopes of these ridges and their irregular outline is in marked contrast with the flowing curves and rounded outlines of the granitic till of this region. The two more northern moraines

extend eastward across the valley and climb the slopes of the hill beyond. They show several short, gentle zig-zags but their general course across the valley is curved, the concave side being to the north. They are nearly parallel and only a few rods apart. The more northern of these moraines is rather discontinuous, consisting of a well-defined system of ridges separated by low places in the ridge or by short gaps. The mills and the dam are built on the line of this moraine. It is composed of a somewhat sandy till, pell-mell in structure generally, but in places faintly stratified and partially water-washed, a sort of transition into kame sand and gravel. The more southern of the two long moraines is higher and more continuous than the northern one. It rises from ten to twenty feet above the marine clay of the valley and has been cut through by the railroad to a depth of about fifteen feet. It is composed of till which contains much fine clay and shows few or no signs of water-wash, and it affords a much larger proportion of well-scratched stones than do the surface layers of the ordinary till of that locality. A few rods east of the mills is a pit whence much rounded gravel has been taken. The excavation shows the till of the terminal moraine overlying the gravel and rounded cobbles. This gravel is part of a system of glacial or "kame" gravels which extends from Waldoboro about five miles northward, most of the way lying near the Medomac. It is one of the discontinuous systems of kames characteristic of that part of Maine—consisting of short ridges like kames yet arranged in long north and south lines like osars. The domes or ridges are separated by gaps of from a few rods up to one-fourth of a mile or more. Of course that part of this kame system which is south of the terminal moraines must have been deposited before the recession of the ice northward to Winslow's Mills. Even to the north of this place the main line of kames does not show an immediate change of character and it too was probably formed before the recession of the ice and deposition of the moraines. But east of the main system of kames and north of the moraines are a number of low scattered kame hummocks and short ridges somewhat parallel to the terminal moraines and probably contemporaneous with them, at least with a part of them.

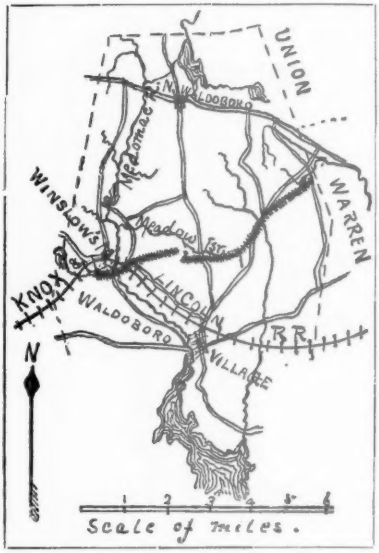
I looked with especial care for exposures showing the relative positions of the moraines and the marine clay. The Champlain clay is much thinner in this valley than in that of the Kennebec. Many of the kame ridges along the Medomac are plainly overlaid by the clay, but no fresh exposure could be found showing the relations of the moraines to the clay. The surface indications were that the clay overlies the base of the moraines. My exploration was incidental to other work and did not permit excavation.

As before stated the moraines climb the hill on the east side of the Medomac. They rise to a height of about 100 feet above that stream. The more northern moraine soon almost disappears, but the southern ridge is conspicuous for about one mile. It is a two-sided ridge, its southern slope being as steep as moraine stuff will lie, and for a part of the way the northern slope is nearly as steep. The ridge everywhere contains more bowlders than the ordinary till of the region. Many of these bowlders are from five to fifteen feet in diameter. The moraine rises from ten to twenty feet and is of variable width, in a few places being ten rods wide, usually narrower. For a short distance it serves as a natural roadway through a swamp, and is locally known as the old railroad grading. It here rises steeply from eight to fifteen feet on each side, and is so narrow that there is just room enough for a log road on the top. The material is here very coarse; in fact the ridge is simply a wall of bowlders. A short distance east of this swamp the moraine disappears near the eastern brow of the hill, but begins again about one-fourth of a mile to the southeast. The topography of the country accounts satisfactorily for this gap. The hill, on its east side, overlooks the valley of Meadow brook, a small stream which flows northwestward into the Medomac. Also there is a valley which extends nearly north from the gap in the moraine. Two favorable lines for ice-flow converged at this point. Naturally the deeper ice of the valley reached a point farther south than the thinner ice which abutted against the hill to the west of Meadow brook, and its moraines are larger. After passing the gap we come upon the moraines on the eastern slope of this hill at a height of about 75 feet above Meadow brook. There are here several nearly parallel ridges extending eastward, also a line of hummocks reaching northward along the base of the hill for a short distance. They are all well sprinkled with large bowlders. The moraines cross the road leading from Waldoboro to North Waldoboro at Benner's mill, on Meadow brook, the road passing through a narrow gap in the ridges. East of this road the several ridges unite into a single ridge which rises steeply on each side from 30 to 60 feet. It is here locally known as "The Ridge," and in form resembles the osars. A broad and flat deposit of glacial gravel begins a few rods south of the moraine and extends for about one mile southward along the road to Waldoboro. I could not trace the kame quite to the moraine, though it nearly reaches the end of one of the outlying ridges which are found west of the road. The marine clay here overlies the kame and appears to overlie the base of the moraine.

A short distance east of Benner's Mill the moraine curves around from east to northeast, and within less than two miles

comes out to the road leading northward from Waldoboro to Union village. This road is made on top of the ridge for more than one mile, part of the way through a somewhat swampy region which would be difficult of passage but for the natural embankment. Here also the marine clay appears to overlie the base of the moraine. Approaching the east line of the town of Waldoboro this road is about one-eighth of a mile north of the moraine, which becomes lower and less continuous, and seems to end within a short distance from the line between Waldoboro and Warren. It ends within about one-fourth of a mile from the osar system which extends from Palermo to near Warren station on the K. & L. R. R. To the east lies a level country for a half mile or more, so that it is not cut off by a line of hills or other obvious barrier in that direction.

The country lying east of the Medomac river and north of the moraine is diversified by numerous low hills, or perhaps it had better be described as a rolling plain. I estimated that few if any of these hills rose more than about 100 feet above the surrounding level. The hills did not cause a gap in the moraine except at two or three points. The country rock weathers so rapidly that the glacial scratches had disappeared from all the exposed ledges observed. The direction of glaciation near the moraine therefore was not determined. Some large ridges and heaps of till are found about a mile north of the end of this moraine, but their origin is uncertain.



The elevation of the Waldoboro moraine is such that if it was deposited at the time when the sea stood at its highest level during the Champlain epoch, it must have been formed at a depth of from 50 to 175 feet below the surface of the water. I did not find a good section showing clearly the relations of the moraine and the marine clay. Excavation will perhaps be needed in order to determine this important point. In the absence of conclusive evidence as to the time of the formation of the moraine, we can only avail ourselves of indirect evidence. In

general the moraine contains a much larger proportion of clay and fine material than the terminal moraines of the Androscoggin glacier, a fact which favors the theory that it was formed in the water where the ice confronted the ocean. There are hills to the south of the moraine high enough to have formed islands in Champlain time. If the ice met the sea at the place of the terminal moraine, both the ice and moraine would be partially protected by these supposed islands from the force of the Atlantic waves. If the moraine was deposited before the water rose, then it would twice be under the surf during the rising and falling of the sea. If so, then the protection of the islands must have been very perfect, for there are few signs of marine wash on the moraine. It seems more likely that the sharpness of outline of the ridge is due to the fact that it was deposited under the sea, and only once has been under the action of the surf. Other considerations might be stated which favor the hypothesis that the moraine was formed at a time when the sea stood at a much higher level than now, but discussion of the subject is postponed until after further study in the field. On the whole, I consider it probable, but not certain, that the ice here flowed into the sea at the time the moraine was being formed.

Several lines of high hills cross the state of Maine from S. W. to N.E., transverse to the line of glaciation. The low cols in these hill-systems often served for the passage of the kame and osar rivers, and they are also often bordered by many irregular masses of till. These are not steep, transverse ridges like those above described, but are somewhat gently sloped heaps of various shapes and they lie in various directions. As the interpretation is doubtful, no detailed account of them is here given.

Colorado Springs, December, 1886.

ART. XL.—*Note on the enlargement of Hornblendes and Augites in Fragmental and Eruptive Rocks;* by C. R. VAN HISE.

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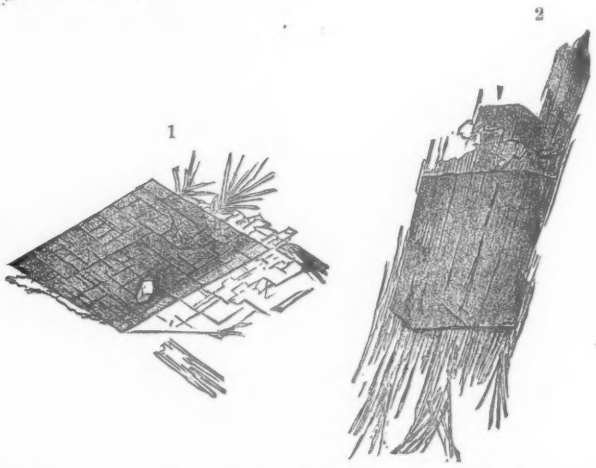
IN the number of this Journal for September, 1885, I described the enlargement of hornblende fragments in certain conglomerates of northeastern Minnesota, showing that grains of hornblende, after deposition in a sedimentary rock, may, under favorable conditions, continue their growths. The chief object of the paper was to show that enlargements of this sort may help to produce in fragmental rocks the condition ordinarily known as metamorphic. Entirely similar enlargements of hornblende, but in *massive eruptive rocks*, are described

by Friedrich Becke in Tschermak's Min. und Petr. Mitth., vol. v, part ii, 1883, in a paper entitled "Eruptivgesteine aus der Gneissformation des niederösterreichischen Waldviertels." The following quotations and figures are from this paper: "Die primären compacten Hornblende-Krystalle sind sehr häufig von einer Rinde umgeben, welche aus strängeliger grüner Hornblende besteht, die ganz mit der Hornblende des Uralit übereinstimmt. In Querschnitten (fig. 1) beobachtet man die durch Kern und Hülle gleichmässig fortsetzenden Spaltrisse. Mitunter hat der so weitergewachsene Krystall andere Krystallflächen in der Prismenzone, als der Kern. In Längschnitten (fig. 2) sieht man den compacten Kern mit Bündeln parallel angewachsener Hornblendenadeln versehen, welche sich weiterhin zu divergirenden Büscheln auflösen." . . . . "Die Art des Auftretens dieser Fortwachsungen lässt keiner Zweifel, dass während der Ausbildung dieser Fortwachsungen mechanische Bewegungen innerhalb dieses Gesteins nicht mehr stattgefunden haben."



It thus appears that Becke discovered in 1883 the enlargement by secondary growth of individuals of hornblende in an eruptive rock, this change having taken place subsequently to the consolidation of the rock from the liquid state. In fragmental rocks the enlargement of hornblende grains has far greater significance because it explains, in part at least, the nature of the induration of a certain class of rocks.

In studying recently the eruptive rocks of the Penokee-Gogebic Iron-Bearing Series of Michigan and Wisconsin, I have met with cases of new growths occurring upon augite and horn-

blende which are corroborative of, and add something to, the observations made by Becke. The rocks in which these new growths have been found are altered diabases. In some specimens of these rocks the augite has largely changed into hornblende. In these cases in a portion of the individuals of augite the alteration of the augite is partial, while in the other portion it is complete. Ordinarily, as described by Irving,* Williams and others, a single individual of hornblende has resulted from one of augite, the two having the usual definite crystallographic relations. To this secondary hornblende the new hornblende has attached itself. There are here, then, two hornblendes, one of which is paramorphic to the augite, while the other is a new growth. The added hornblende has found room for itself, as in the case described by Becke, by penetrating the surrounding feldspars. Similar new hornblende is also found included in the partly decomposed feldspar in numerous small, fibrous, independent individuals. The new hornblende is of a pale green color; it is not strongly pleochroic; it shows often distinctly its intersecting prismatic cleavage. The crystallographic continuity of the paramorphic and new hornblendes, when the two are contiguous, is as plain as in the case described and figured by Becke, where, however, the first hornblende seems to have been original.

In other diabases from the same region the greater part of the augite is unaltered. Here nearly every individual of this mineral is surrounded by a sheath of hornblende. This hornblende has clearly formed subsequently to the consolidation of the rock, as is shown by the following facts: The hornblende cuts into the surrounding feldspar in the most irregular manner. The augite cores have the forms common in many diabases, being bounded by well-defined broken right lines, or lines somewhat curved, as the spaces left by the feldspars allowed.† Often the new growth has continued farther in places than in adjoining ones, and, as it went on, it has sometimes widened out, forming within the feldspar club-shaped protuberances of hornblende.

In longitudinal sections (fig. 3) the hornblende is more plentiful at the extremities of the individuals than at the sides.

* R. D. Irving, this Journal, July, 1883, and Feb., 1884. Geology of Wisconsin, vol. iv, p. 663.

M. E. Wadsworth, Notes upon the Geology of the Iron and Copper Districts of Lake Superior.

G. H. Williams, this Journal, Oct. 1884, and Bull. U. S. G. S., No. 28.

Frederick H. Hatch, Min. und Petr. Mitth., vol. vii, pp. 75–87.

† In the greater number of these rocks the major part of the feldspar has crystallized prior to the augite, although in certain of them the augite and the feldspar mutually interfere to such an extent as to indicate that the augite began to crystallize before the feldspar had proceeded far in crystallization.

The terminations of these enlargements are sharply serrate. The constituent fibers at times are slightly divergent and

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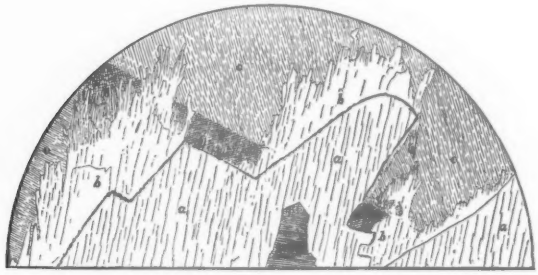


FIG. 3.—*a*, *a*, *a*, portion of an augite core; *b*, *b*, *b*, hornblende enlargements; *c*, *c*, *c*, feldspar.

usually cut deeply into the feldspar. Ordinarily the fine fibrous cleavage of the hornblende is coincident with the cleavage of the augite. However, the angles *c* : *r* in the augite and in the enveloping hornblende show their characteristic relations.

4

In transverse sections (fig. 4) where the intersecting prismatic cleavages of the augite and hornblende are seen, their relations are such as to indicate that the ortho- and clino-pinacoids in the two minerals are parallel.

The crystallographic relations of the two minerals are, then, in both longitudinal and transverse sections, those well known to occur between augite and hornblende paramorphic after it.

University of Wisconsin, Madison, Feb., 1887.

ART. XLI.—*The great Acadian Paradoxides;* by G. F. MATTHEW.

IN this Journal (vol. xxx, p. 73), the writer, in speaking of the occurrence of the great Welsh Paradoxides (*P. Davidis*) in the Cambrian rocks of Newfoundland, alluded to the fact that another gigantic species of this genus was present in the Cambrian basin at St. John. At the time when that communication was written, the St. John species was known only by fragments of the glabella, pleuræ and pygidium. An

almost complete example has lately been found, from which it appears that the species differs from any hitherto described. Its nearest allies are *P. Bennettii* of Newfoundland and *P. Harlani* of Massachusetts, but it has not the "pendent ears" and abortive spine of the former, nor the long (sometimes extravagantly long) spine and round pygidium of the latter. It has a rather smooth test, and the eye-lobes are shortened and placed as in the two species named. It differs from *P. Bennettii* in being brachypleural in the adult stage, and from *P. Harlani* in having only seventeen segments in the thorax. It may be described as follows:—

PARADOXIDES REGINA.

A species of the largest size and having a very wide body.

Head shield greatly expanded, and having the genal angles produced into short spines; glabella broad and possessing two complete furrows; eyes rather short, situated opposite these furrows. *Thorax* with seventeen joints; having the axis very broad, and the ends of the pleura leaf-like, curved, but scarcely reflected, and having the three last joints shorter than the others. *Pygidium* subquadrate behind, with a small axis and with the lateral lobes expanded backward. *Hypostome* subquadrate behind, but having the posterior angles truncated, anterior lobe widely expanded laterally, and having the anterior margin expanded and widely extended.

The specimen is defective where the two anterior glabellar furrows would come, and so it is not known whether these are present or absent. The horizon is Band 1*c* of the St. John group. This species appears to be the largest trilobite which has so far been found in any country, being fifteen inches long and twelve inches across the cephalic shield. Professor W. C. Brögger calculated the length of an example of *Megalaspis acuticauda* found in Norway as sixteen inches (403^{mm}), and the late M. Barrande gave the length of *Asaphus Barrandei*, found in France, as fifteen and a half inches (400^{mm}), but these larger Asaphi are narrower in proportion than the Acadian trilobite.

Among Paradoxides the Acadian species is the largest known to the writer. With *P. Harlani* and *P. Bennettii* it constitutes a group of gigantic forms with more or less foliaceous, and curved rather than reflexed pleuræ, which the writer believes will be found to characterize elsewhere, as it does in Acadia, the Lower Paradoxides beds. From our present knowledge of these forms we indicate the two above named and *P. Regina* as independent species; but if connecting forms should be found, the Acadian and Newfoundland trilobites will stand as varieties of *Paradoxides Harlani.*

ART. XLII.—*On the Kin of Paradoxides (Olenellus?) Kjerulfi;** by G. F. MATTHEW.

THE following remarks are intended as a contribution to the discussion of the comparative age of the Paradoxides beds in Europe and America and the probable position of Olenellus in relation thereto. They are directed chiefly to the consideration of the allies of *Paradoxides Kjerulfi* Linrs., as upon the decision of this point partly depends the correlation of the Atlantic border Paradoxides beds with the Cambrian beds of the Hudson River and the more western part of America.

Mr. S. W. Ford, in an article "On the age of the Swedish Paradoxides Beds," in which he ably reviews the evidence as to the zoological position of *Paradoxides Kjerulfi*,† quotes the succession of the Swedish Paradoxides beds as given by Mr. Linnarsson in 1876, viz:

(6.) Strata with *Agnostus lævigatus.*
(5.) Strata with *Paradoxides Forchhammeri.*
(4.) Strata with *Paradoxides ölandicus.*
(3.) Strata with *Paradoxides Davidis.*
(2.) Strata with *Paradoxides Tessini.*
(1.) Strata with *Paradoxides Kjerulfi.*

* In a communication published in this Journal. xxxi, 472, 1886, the writer stated that *P. Kjerulfi* occurred in Newfoundland, but on further examination of the material in which the trilobite so referred occurs, it seems doubtful if it is that species. The cheeks in the Newfoundland trilobite are free, whereas according to Dr. Brögger the cheeks of *P. (O.?) Kjerulfi* are soldered to the middle piece of the head shield; and there is no free cheek as in the typical Paradoxides. The example supposed to have been found at Kennebecasis River is, for the same reason, not *P. Kjerulfi.* Dr. Brögger has stated that the pygidium is unknown and probably small; but until this part is recovered and found to be of the same kind as that of the American Olenelli, we cannot with confidence speak of it as belonging to the genus Olenellus; I have therefore preferred to use in this article the generic name under which it was originally described. Dr. Brögger now gives *Wahlenbergi* as the specific name of this trilobite, but on referring to the place where this name is used it appears as one of a list of species, but is not accompanied by figure or description.

† This Journal, vol. xxxii, No. 192, Dec., 1886.

The position of No. 4, or the beds carrying *P. ölandicus*, was said to be doubtful, as not determined by observed sections of the Cambrian beds; it is however the horizon assigned by Mr. A. Sjögren the describer of the species.

Having observed the stratigraphical position of the Acadian representative of this species (*P. lamellatus* Hartt) to be below the beds which carry the Acadian species allied to *P. Tessini* the writer ventured to inquire of Professor Lindström of Stockholm what the position of *P. ölandicus* was, and by a letter lately received from that gentleman he learned that "in 1875 Professors Nathorst and Dames found the zone of *P. ölandicus* to be *older* than that of *P. Tessini*."

The importance of this fact is the greater from the many points of affinity between this species (*P. ölandicus*) and *P. Kjerulfi*. Mr. Ford in his valuable article above referred to, speaks of "a number of strong points of resemblance" between these species, but does not specify the point wherein the relationship consists, but some of the more salient ones will appear from what follows.

If it could be shown that the lower part of the Paradoxides beds in America is characterized by a group of species which differ from the typical Paradoxides found higher up, an advance would be made in distinguishing the several parts of the Cambrian system on this side of the Atlantic. That there is such a group at the base of the Paradoxides zone in Europe and America is now I think sufficiently clear; and some of the points of structure which mark it are the following: *The test is granulated, the pleural grooves are short and strongly marked, the glabella and rachis are prominent, the fixed cheeks are narrow, the eyelobes are shortened and drawn in at the base, the genal spines are short (and channelled on the upper side?).**

In *P. Kjerulfi* the pygidium is not known; in *P. ölandicus* the pygidium has four points; in *P. lamellatus* the pygidium has two points.

In the second and third species the pygidium is that of Paradoxides, not of Olenellus, and it is a matter still to be determined whether the first named species is a true Olenellus in all respects, and especially as regards the pygidium.

In *Paradoxides Acadicus* we have another primitive type, but not of the same section in Paradoxides as those above named. The recovery of the parts show that it possesses the long sigmoid pleural furrow of the more typical forms of the genus and not the comma-shaped (almost pear-shaped) furrow of the three species above named. It has not yet been found so low down in the Acadian (Cambrian) measures as some other

* They are channeled in *P. Kjerulfi* and *P. lamellatus*.

species; but its companion-form in Europe has been found to be associated with *P. ölandicus* whose place is next above *P. Kjerulfi.*

It is somewhat remarkable that *P. Eteminicus*, which is the American equivalent of *P. rugulosus*, should be one of the first species of Paradoxides to appear in the Acadian region, while in Scandinavia it is not known until after the appearance of *P. Tessini*, a species which is represented in Acadia at a higher level by *P. Abenacus;* possibly its later appearance in Europe is due to the higher measures presenting a more favorable habitat. In Acadia gray shales are followed by dark shales, but in Scandinavia the conditions were reversed, as the shales with black streak are the oldest.

The succession of the Paradoxides in the St. John Group, as far as it has been ascertained, is the following:

	Division I.				European Representative.
	Band *b*	Band *c*		Band *d*	
		1	2		
Paradoxides Kjerulfi*	?	—	—	—	P. Kjerulfi.
Paradoxides lamellatus	—	†	—	—	P. ölandicus.
Paradoxides Eteminicus	—	†	†	—	P. rugulosus.
Paradoxides Micmac	—	†	†	—	P. palpebrosus?
Paradoxides Acadicus	—	—	†	—	P. Sjögreni. P. Harknessi?
Paradoxides Regina‡	—	—	†	—	P. spinosus?
Paradoxides Abenacus	—	—	—	†	P. Tessini.

Of the six divisions of the Paradoxides beds of Sweden, given by M. Linnarsson, the three oldest have been recognized in the St. John Group; the presence or absence of the three higher remains to be determined.

In regard to the form of the glabella in *P. Kjerulfi* there seems to be considerable diversity; in those from the green slate of Tomten in Norway figured by Linnarsson the front is wider than the base; but in those figured by Kjerulf the front lobe is as narrow or narrower than the rest of the glabella; one of Professor Kjerulf's figures show *P. Kjerulfi* to be brachypleural when half grown.‡

St. John, N. B., Dec., 1886.

* Fragments have been found which may belong to this species.

† A gigantic species intermediate between *P. Bennettii* and *P. Harlani.*

‡ Om Skuringsmærker, etc., II. Sparagmitfjeldet (Christiania, 1873), p. 83, fig. 3.

ART. XLIII.—*On Taconic Rocks and Stratigraphy, with a Geological Map of the Taconic region* (Plate XI); by JAMES D. DANA.

Part II. The Middle and Northern Part.

(Continued from p. 276 of this volume.)

THE map of Middle and Northern Berkshire mentioned in the preceding part of this paper (p. 270 of this volume), is herewith published. For detailed explanations of the symbols and letters used on the map, the reader is referred to p. 206 of volume xxix (March, 1885) of this Journal.* The map illustrates fully the points presented on pages 271–276: (1) the eastern limestone with its intercalated and often isolated ridges of schist; (2) the passage of the eastern limestone belts into the western—as that of the Vermont through North Bennington, into the Hoosac and Petersburg area, that of the Vermont, through Williamstown and Hancock, into the Lebanon and Canaan area, and the near approach of the latter at Canaan to junction with the Stockbridge limestone in West Stockbridge; (3) the variations from normal directions and continuity in the belts, apparently due, for the most part at least, to earlier topographical conditions—exemplified (1) in the Williamstown and Clarksburg region; (2) in the town of Bennington; (3) in the

* For the convenience of the reader, the following explanations of the lettering on the map and the symbols in the figures beyond, are here repeated in brief. Q, quartzyte; M, mica schist; M̄, (not used before) hydromica schist; Gn, gneiss; A, Archæan. In the figures, a dot stands for *quartz*, a hyphen for *mica*, and a cross (+) for *feldspar*, a *long hyphen* — for hydrous mica; dots for quartzyte; alternating dots and hyphens · - · - for mica schist; alternating dots and long hyphens · — · — for hydromica schists; and alternating dots, hyphens and crosses (· - +) for gneiss; alternation of four dots with a hyphen (· · · · - · · · · -) for micaceous quartzyte; alternations of two or three dots with a hyphen (· · - · · - ·) for quartzytic mica schist; the lines alternate with a rule, for a bedded or schistose rock as mica schist, hydromica schist and bedded quartzyte; and groups of 3 or 4 lines with rule between, for gneiss or slightly bedded quartzyte. In the section the dip of the lines is the true dip; an unfilled space in the inner part of a figure of a section signifies that the dip was obtained from exposures over the surface, and not from an actual transverse section; while an unfilled interval between the lines indicates a concealment by soil, and the figures added, the width of the covered surface; the end of a figure to the right is always the eastern or northern end; a circle with a letter inside means a quarry or ore-bed, and the letter indicates the material afforded: Fe, the iron-ore, limonite; Q. quartzyte as hearthstone or sand. The map was plotted on the maps of Beers's Atlases, which, while of great value for the purpose, have not the accuracy of a thorough survey of the region; and hence some unavoidable errors are introduced which I could easily make right on a new map of equal size (mostly two inches to the mile), and having all of its details, including the positions and names of owners of all houses which aid in marking localities or as a base for measurements. Some of the areas, as the narrow one of schist in New Alford, might take a more probable form on such a map, since the roads have been the chief means of fixing the courses of the outlines. As in the map of Southern Berkshire, it was not possible to adjust to the Massachusetts map the lines on the portion of Connecticut added to it, so it is as regards the addition of Vermont. Scale ½ inch=1 mile.

eastward extension of the Pittsfield limestone and the quartzyte south of it, and (4) in the Bear Mountain region with Monument Mountain west of it; the localities of Archæan being recognized by the presence of hornblendic rocks, sometimes zircon-bearing and chondroditic limestone, from eastern Tyringham northward and marked on the map by the letter A. The colored portion of the map is that covered by the limestone.

The next subject is:

2. *The Limestone and the conformably overlying strata.*

1. *Kinds of rocks and their distribution.*—The *kinds of rocks* observed in central and northern Berkshire, with the adjoining border of New York, are the same as in the southern portion, already considered, except that the mica schists north of the town of Sheffield have not yet been found to be staurolitic.

The limestone is mostly dolomitic, except to some extent (as made known by analyses in the Geological Report of Professor E. Hitchcock (1841, p. 80), in the more western towns of Berkshire. The same analyses show that the beds are rarely true dolomite, but partly calcite, by having a deficiency of magnesia, and that consecutive beds vary much in constitution. The subject needs investigation.

The rock varies in grade of crystallization, being coarsest (*a*) to the southward, and also (*b*) to the eastward. It varies in color, being usually white to the eastward, often gray in the more western belts of Berkshire, and generally gray west of Berkshire. It varies in impurity, being often very micaceous in the vicinity of the schist ridges, so as sometimes to be deceptive, and very quartzose near the quartzyte. Tremolite and white pyroxene, abundant minerals in the Sheffield limestone and its continuation southward, (to New York Island, if all is the same limestone, as is probable,) occur also in belts of Monterey, eastern Great Barrington, Tyringham and Lee; and minute tourmalines are occasionally present.

The schists are hydromica schists to the westward and mica schists to the eastward, along with indefinite intershadings through chloritic hydromica schists. Hydromica and chlorite are hydrous species, so that the difference in the metamorphic schists mentioned is largely a difference as to the presence of water; a hydromica containing 4 or 5 per cent (but like mica in other constituents), and chlorite containing 12 to 14 per cent. In the Greylock range the chloritic hydromica schist passes locally into a hydromica gneiss, which I designated in 1877 a protogine variety of gneiss.*

The more western schists west of Canaan, N. Y., are much like a glossy roofing slate, showing in the color no evidence of the presence of chlorite, though it may contain much of it.

* This Journal, II, xiv, 258, 260.

In the main Taconic range, along the Massachusetts boundary, the schists are chloritic hydromica schists, and on the eastern sides often garnetiferous, especially to the southward. In an east and west line through South Williamstown and Greylock they continue to be chloritic hydromica schists from the New York boundary to the eastern slope of Greylock, or seven miles, where are some portions that might be designated true mica schist; a mile and a half east of Greylock summit, near the east foot of the Greylock mass, the rock would be ordinarily called mica schist; and this is true, also, farther north, abreast (west) of the village of North Adams, as seen at the little railroad tunnel, although the mica is slightly greasy to the touch.

The mica schist is sometimes muscovite schist, often biotite schist, but generally both micas are present.

Looking at Berkshire as a whole, in the part of it *east* of a straight line drawn through the county, southward, from Greylock to the northeastern corner of Mt. Washington in South Egremont, about S. 15° W. in course, the schists are nearly all mica schist, while to the *west* of the same line, they are nearly all chloritic hydromica schist. A ridge in Lanesboro (which is nearly on this line), has the schist intermediate between hydromica and mica schist, inclining most to the latter. This line throws to the *west* the high ridges, Tom Ball and Maple Hill, of West Stockbridge, which are of chloritic hydromica schist, and to the east, ridges near by on the east of these. But to one going over the region the transition would be found to be a very gradual shading from one to the other, some portions at the northeastern foot of Tom Ball almost meriting a place with the mica schist.

Fifteen miles south, in Canaan, N. Y. (nearly west of Pittsfield), the schist *west* of the limestone is a very thin, slaty, glossy roofing slate; that of the ridge east of it, north of Queechy Lake, a coarse chloritic hydromica schist, except near the boundary of Lebanon (at B, on the map, a high point called Douglass Knob) where it becomes quartzose, a very hard chloritic quartz rock, not schistose; the high knob is the source of the famous bowlder trains that cross Richmond into Lenox, first studied out by Dr. Stephen Reid, of Pittsfield.

East of the N. by E. and S. by W. line drawn from Greylock to the northeast base of Mt. Washington, the larger part of the mica schist is extremely arenaceous; and it often graduates imperceptibly into a bedded quartzyte, or alternates with strata of quartzyte, both that of the thin-bedded kind, and of the hard and massive, precisely as described in Part I of this paper for Southern Berkshire and the adjoining part of Connecticut; and, as there, the rock usually contains minute tourmalines. The narrow ridge entering the town of Great Barrington from Sheffield west of the railroad, consists of bedded quartzyte

slightly micaceous. The ridge just north of this, situated to the west of the village of Great Barrington, consists partly of mica schists, of nearly normal type, though over-arenaceous, and largely of micaceous bedded quartzyte, with also much hard quartzyte especially to the north; and just northwest, a low quartzyte area extends to the base of Tom Ball; while northeast are others of quartzyte. North of Housatonic village quartzyte beds alternate with true mica schists. Monument Mountain has two strata of hard quartzyte with quartzytic mica schist between them; but the latter passes into a massive fine-grained micaceous rock, gneiss-like in aspect, which is calcareous (effervescing with acid). East of Great Barrington, a very similar gneissoid rock, somewhat calcareous, is the chief material of the lower part of a high ridge, and shows out gneiss-like in the great tumbled masses at the base of the bluff at the north end and where quarried; at the summit, the ridge is bedded micaceous quartzyte, passing into micaceous or quartzytic mica schist.

The quartzytic mica schists and micaceous quartzyte constitutes also Rattlesnake Mountain in Stockbridge and other ridges farther north to Adams. But for details I refer to the map.

A microscopic examination of thin slices of the gneissoid rock of the ridges east of Great Barrington, and of that in Monument Mountain, shows that, besides much quartz, considerable mica and a little calcite, it contains also considerable orthoclase, and merits the name of a quartzytic gneiss or a gneissic quartzyte.

In Tyringham there is a well characterized gneiss overlying the limestone.

The destructibility of the bedded quartzyte and the quartzytic mica schists is generally a marked peculiarity. It is very common to find decay extending down one or two hundred feet, concealing deeply the *solid* rock. The decay sometimes leaves a hillside covered with loose blocks of hard quartzyte, derived from harder layers, or isolated harder portions, in the strata. The porosity of the rock renders it permeable by waters to great depth; and then the presence of a little removable calcite or orthoclase makes destruction easy.

2. *Limits between the limestone and other areas.*—The approximate limits of the limestone areas are in general easily obtainable, as outcrops are numerous. But there are many regions where, owing to the covering of drift and the extensive decomposition of the rocks (the arenaceous schists and the bedded quartzytes), the uncertainties are great.

The first of these sources of doubt, as I have already said, affects widely the west sides of hills and mountains, the side that faced obliquely the moving glacier. The other may occur any where. Rattlesnake Mountain, in Stockbridge, is an ex-

ample of an obscuring of the north, west and south sides by both causes. Maple Hill, in West Stockbridge, has much of its west and north sides under deep drift—250 feet at an ore-bed on its northwest slope. These are examples. Long experience in the region helps one to probable conclusions in many such cases, but in others, doubts will remain. In Adams the limit at the west foot of the Hoosac Range is one of the worst cases—a region of half a mile or more intervening without outcrops; and between the central quartzyte belt of the town and the range, it is still a question with me whether the quartzyte formation with its arenaceous mica schist may not extend for a considerable distance quite to the base of the mountain. The first rock encountered on the ascent of that part of the mountain is a light colored very arenaceous mica schist, like beds in the quartzyte area, and also like much of Hoosac Mountain elsewhere. The Clarksburgh region is one of much doubt on account of the few outcrops.

The quartzyte bowlders over a region are an assistance toward a knowledge of what is below, since they are often not drift bowlders, but, as explained above, masses left where they now are by decomposition. But again they are very deceptive evidence; for the region just mentioned, east and southeast of Adams, has striking examples of an abundance of quartzyte bowlders over the surface where the rock below is limestone.

3. *Stratigraphic relations.*

Limestone, hydromica schist, mica schist and quartzyte, and intermediate gradations between these, being the rocks within the limestone limits, the question is now as to their stratigraphical relations.

1. *No general overthrust faulting.*—The facts with respect to the relative positions of the rocks here set forth require no allowance for possible overturns except such as affect single or a few associated folds. That there has been no great overturn affecting the region as a whole, or over a large part, is proved by the following characteristics of the region and its rocks.

The gradual transition in *kinds* of rocks and in *grade of metamorphism* from east to west over the Taconic region; the like grade in the metamorphism of the limestone and the schist adjoining it, through all parts of the region; the absence of eastern rocks from the western part, and of western from the eastern; the gradual transitions in many cases from limestone to schist through impure micaceous and sandy limestones; these are all indubitable evidences on this point.

Not only are the transitions from limestone to schists marked by micaceous, arenaceous, and other similar impurities, but also in many places by ferriferous conditions in both the schist

and limestone, and preëminently in the limestone which occurs adjoining the schist at intervals for long distances in western Berkshire (in Lanesborough, Richmond, and West Stockbridge and less abundantly in other towns), as well as in Vermont to the north and Connecticut and New York to the south—the limonite beds attesting to it. This is good evidence that the beds are natural in sequence; that there has been no great lateral move by a thrust-fault over the region of Berkshire and eastern New York, disturbing the order of stratification.

2. *The true stratification is not disguised by foliation, or slaty cleavage, or other effects of pressure.*—Questions as to slaty cleavage, foliation, schistosity, are not a source of serious difficulty in the Taconic region. If the rocks were all slates, all mica schist, all hornblende schist, or all limestone, that is, were wholly of one kind, the uncertainties as to bedding or not might be well-nigh insurmountable. But where the three kinds are together in alternating layers or strata, the doubts disappear, for there is then distinct stratification between layers or strata of different kinds in constitution, and the study of it is like the study of stratified rocks in non-metamorphic regions. If in such cases the schistosity of a schist is parallel to the planes of junction between the layers or strata of the different kinds, its planes are essentially those of bedding whatever their origin; and this is eminently manifest in Berkshire where one of the rocks is limestone. Alternation in strata or layers of different kinds of rocks cannot be a result of pressure. The principle presented is as true for Archæan rocks as for any others and affords a criterion which is of great value in their investigation.

For the reasons stated, the Taconic region is as much a region of stratified rocks as that of western New York. It has its *strata* of limestones, sandstone (quartzyte) and schist, the study of whose positions is stratigraphical study, far outside of microscopic investigation, though deriving great aid from such investigation as regards the constitution of the beds, metamorphic changes, and other points. The planes of junction between the strata are open to observation. And it is wonderful how very generally the planes of lamination in the schist correspond in position with these planes of junction. It is so general that the geologist of the region comes naturally to the opinion that it is exceptional for foliation to be any other than lamination conformable to the bedding. Stratification in the region stands out with the distinctness that characterizes ordinary regions of stratified rocks, and the anxious and sceptical petrographer has no occasion for his doubts, or for his expectation of settling all such cases with the microscope.

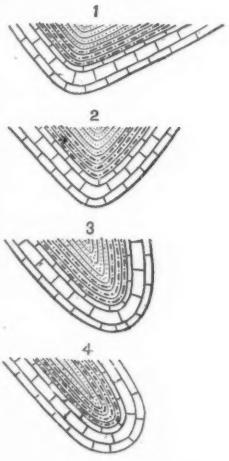
In many places, moreover, the strata are piled to mountain height while still nearly horizontal in the position of the beds. Such nearly horizontal lamination is not due to pressure attend-

ing uplift—the source of foliation or slaty cleavage; if to any pressure, it is to vertical, like that of the gravitating mass, or that pressure to which a shaly structure is attributed.

3. *Stratigraphy of the region.*—The question in this region of upturned, flexed and crystalline rocks, is, as in Part I—

Which is normally the upper stratum, the limestone, or the schist? Are the schist ridges usually synclinals or anticlinals? The fact that in the southern part of the Appalachians—the Alleghany Mountains—the *ridges* are usually synclinals shows that the view as to their being synclinals in the Taconic region, if it be sustained, is not exceptional.

a. Characters of the flexures.—The flexures over the area have usually the north-by-east direction or strike characterizing the main Taconic range. They generally, and probably always, have the axis inclined instead of horizontal—sometimes to the northward and as often to the southward, the two kinds being necessarily accompaniments in a complex system of warping (as not badly illustrated in the sleeve of a coat at the elbow-bend inside). The inclination is sometimes indicated by the form of the ground-plan of the schist ridges—that is by its widening from one end to the other. An example is seen on the map, west of the village of Great Barrington: the area narrows southward; and it necessarily follows that the axis of the flexure inclines to the southward if it is an anticlinal and to the northward, if a synclinal. Two similar areas occur in the town of West Stockbridge, those of Maple Hill and Tom Ball (the latter extending into the town of Great Barrington); others in Lee and Pittsfield.



The dips, moreover, often indicate the precise kind of flexure. At the narrow end, they are usually eastward on both the east and west sides, as in a careened trough, as in the annexed (fig. 4); but at the other, while eastward on the west side, they are often *westward on the east* side, indicating a *tray-like synclinal* (fig. 1)—the whole fold being, therefore, an inclined tray-like synclinal with the narrower end of the synclinal, or that where the effects of pressure were greatest, careened or overthrust. The succession of figures 1, 2, 3, 4, represent sections of a mountain ridge having a broad tray-like synclinal structure (1) at one end and a careened synclinal (4) at the other, with two of the intermediate conditions in 2 and 3; and if the series of figures is viewed upside down, they then serve to illustrate the corre-

sponding variations in an anticlinal flexure. (These figures are repeated on the map and numbered 52).

b. Descriptions of Sections.—The figures on the accompanying map of Berkshire and in the text beyond represent some of the many sections observed in the region: and, as already explained, they indicate also the kinds of rocks. The descriptions of the sections, as well as the numbering, here commences at the south. Numbers 1 to 21 are those already published in Part I. Of the 30 in this Part, figures 22 to 30 have appeared in my earlier papers on Berkshire, and are presented at this time only on the map; and I would refer to those papers for details with regard to the stratification.*

Section 22 (map). In the Konkaput Valley, on its northeast side, at the southwestern base of the high land from which Bear Mountain rises; part of the section is south of the road, and the rest north of it; the latter part terminates in "Devany's hearthstone quarry" (not now worked) which is situated a little to the eastward of the line. The several alternations of quartzyte and mica schist with limestone, the micaceous character of much of the quartzyte, and the small dip northeastward are the interesting points.

Sections 23, 24 (map). On the southwest side of the same Konkaput Valley opposite the locality of the preceding section, at the base of the high ridge. In section 23, the limestone does not appear at bottom, the soil covering it; but farther south, along the base of the same ridge, sections occur like 24, showing the true relations of the limestome to the quartzyte and the overlying mica schist; the rocks are like those of section 22, but the dip is reversed as if opposite parts of an anticlinal. The localities are in the southeastern part of the town of Great Barrington.

Section 25 (map). Just *east* of the Housatonic River at the village of Great Barrington, extending eastward from the limestone in the valley at the base of the high ridge (with a fault separating it from the rest), to the top; a gneiss-like rock below, a micaceous quartzyte at top.

Section 26 (map). *West* of the village of Great Barrington—a ridge consisting of arenaceous mica schist, micaceous quartzyte and bedded and non-bedded quartzyte. Limestone makes the western high part of the ridge opposite the village. Unfortunately, no section of the north end of the ridge is open to view.

Section 27 (map). Section 27 crosses a low N.-S. ridge just northwest of Vandeusenville (three miles north of Great Bar-

* This Journal, vols. v and vi, 1873, and xiii and xiv, 1877. The locality of each section is marked on the map by large numerals corresponding with the numbering of the figures here used.

rington, and east of Long Lake Valley), which consists mostly of quartzyte, but has quartzytic limestone within it, and limestone on the west side and arenaceous mica schist near the east base in Williams River Valley. At the outcrop the limestone portion of the quartzyte, as developed by erosion, shows that the dip of the quartzyte is beyond question conformable to that of the limestone.

Sections 29, 30 (map). Section 29 crosses the northern part of the schist ridge Tom Ball, where it is a tray-like synclinal, and 30 the middle portion where, as farther south, it is a careened synclinal. The number 29 on the map (back of a house near the bridge over the river) shows where the westward dip of the limestone underneath the schist may be observed. At this place, on the *east* side of the river and railroad, the limestone dips eastward, indicating an anticlinal in it crossing the valley. The high ridge of West Stockbridge called Maple Hill commences with a high eastward dip just north of where Tom Ball ends, and widens northward.

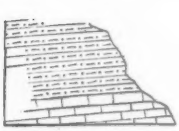
Section 31. On the north side of an east-and-west road a mile north of Housatonic Village (a road leaving the Housatonic Valley nearly opposite the "Old Furnace." It shows a low limestone anticlinal with mica schist covering either side. A short distance to the northward of the locality, the middle and eastern sides are cut away by denudation; the western continues northward as a ridge having a top of schist and a high base of limestone, both dipping westward as in the section. Southward the limestone disappears *beneath* the schist, the eastern part of which dips eastward toward Monument Mountain (only a mile distant on the east of the Housatonic) and becomes apparently the lower schist of the west end of the mountain with limestone beneath it.

To the southwestward of the above (see map) occurs a low narrow ridge which consists of quartzyte, and corresponds apparently to the overlying quartzyte of the same (west) part of Monument Mountain; and on its west side it is mica schist, answering to the schist of the mountain overlying the same quartzyte. The same rocks outcrop farther south through, and by the west side of Housatonic Village.

Sections 32, 33. On the road between Glendale and the Williams River Valley in North Stockbridge, and north side of road, at the south end of a spur of Lenox Mountain. Section 32 shows the very nearly horizontal position of the schist (a hydromica schist that approaches closely mica schist) and underlying limestone. Nearly the same dip may be seen farther west where the road descends into Williams River Valley. The limestone extends up 200 feet above the valley on the steep side of the mountain, and a railroad runs near the junc-

tion; and near the Fuarey quarry, section 33 was taken, showing the dip of the limestone under the schist. The synclinal character of Lenox Mountain, and the tray-like character at the

31. 1 m. N. of Housatonic Village. W. of "Old Furnace"



32. W. of Glendale.

33. W. Stockbridge, Fuarey's Q.

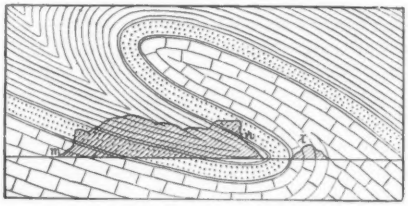
south, is sustained by the sections; and this indicates that the limestone of West Stockbridge and Stockbridge are the same continuous stratum; a fact further apparent from their actual continuity to the northward in the town of Pittsfield.

Section 34. Through Monument Mountain from the east side of the Housatonic River, at Housatonic village, in a southwest direction, nearly to the road from Great Barrington to Stockbridge. It gives the true dip at the east and west extremities of the section, and the mean dip of the intermediate portion; also the dip of the limestone at a quarry to the east of the eastern foot, near the Stockbridge road. It has two masses or strata of quartzyte with arenaceous or quartzytic

34. Across Monument Mtn., Southeastward from Housatonic Village to Stockbridge road.

mica schist between, and a thin bed of the same schist underneath the western quartzyte. No exposed section shows the rock underlying the western lower schist; but the dips of the schist to the westward of the river, with the underlying limestone, as explained above (p. 401), leave little doubt that the limestone passes beneath the mountain. The upper and lower quartzyte may be the same stratum in an overthrust fold as represented in the following figure. In that case, the limestone off the east end of the mountain is a part of the underlying limestone at the upward bend. The position of the quartzyte and mica schist strata west of the mountain and of the Housatonic River harmonizes with this view, as shown in the explanations already given (p. 401). A line drawn from the elevation

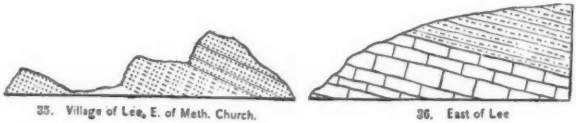
east of Great Barrington southeastward to the locality in the Konkaput valley affording section 23, is parallel to the Monument Mtn. section, and about three miles distant; it is similar in rocks and small dip, but reversed in dip, and in having the limestone at the *west* end nearly vertical in bedding. They seem to be counterparts, in the system of flexures of the same rock strata.



Monument Mtn. Ideal Section.

While the above view of the flexures affords a sufficient explanation of the stratification, it may not be the right one. There may be actually two distinct beds of quartzyte, as the figure represents; or possibly, the beds may be faulted at the middle of the section, and a displacement sufficient to make *apparently* two beds of quartzyte out of one; and this last view has in its favor the fact of much irregularity of dip on the line near the top. Again, there may be a reversal of the fold, making the quartzyte underlying quartzyte or Cambrian, and the schist of the mountain an *inferior stratum of the same formation*, with the limestone above the quartzyte and also an overlying stratum of schist.

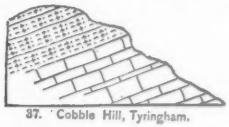
Sections 35, 36. From the village of Lee. Section 35 runs eastward through the western and larger of two nearly parallel areas starting from a point near the M. E. church in the village. Hard quartzyte is overlaid by arenaceous or very quartzytic mica schist, and this again by quartzyte. Section 36 is from



35. Village of Lee, E. of Meth. Church. 36. East of Lee

the western side of a more eastern ridge, just east of the village; it is remarkable for the absence of quartzyte, and the normal character of the mica schist, notwithstanding the nearness and close relations of the two areas. At the top of this ridge the schist bends over rather abruptly and becomes nearly vertical. It may be faulted.

Sections 37–39 in Tyringham. Section 37 is on a line extending nearly westward from Tyringham village to the summit of "Cobble Hill" which stands in the valley near the village. Fig. 39 is a view up the valley, looking southward, showing the hill (at *c*) in the valley. The limestone dips beneath mica schist and gneiss, and the latter is the predominant rock.

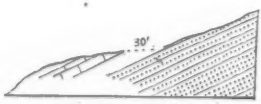


37. Cobble Hill, Tyringham.

38. W. of Cobble Hill, Tyringham.

The limestone and schist of Cobble Hill extend westward, and are the rocks at a high level (300 feet or so) on the west side of the valley just south of an old Shaker establishment; and they extend from that place northward at about the same level all the way to South Lee, keeping nearly the same high level. At a point a few rods south of the Shaker establishment (now a summer boarding house) the limestone and schist outcrop on the road side, as in section 38, the former disappearing *underneath* the latter; but whether *normally* underlying or not is an undecided question.

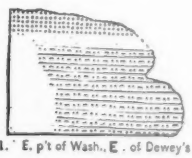
39 Tyringham



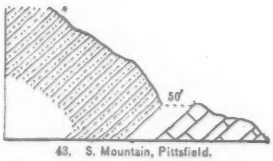
40. Southern part of Lee.

On the *east* side of the Tyringham valley the limestone *overlies* quartzyte or gneiss, and is not found anywhere much above the level of the valley plain.

Section 40. At the foot of the east slope of Tyringham valley, in South Lee, where bedded quartzyte dips westward at a small angle, crossing the road; but at one place, just south of this crossing, in the field, the limestone is seen overlying the quartzyte with similar westward dip and nearly the same angle.



41. E. p't of Wash., E. of Dewey's



43. S. Mountain, Pittsfield.

Section 41. On the western border of the town of Washington, west of the Hearthstone quarry, and south of the road from Dewey's Station.* A large outcrop of arenaceous mica schist

* On the map, fig. 41, the location of the section is wrongly stated to be *west* of Dewey's Station, instead of east.

with quartzyte, the rock of the region, above. Only a few feet without rock intervenes between the schist and quartzyte.

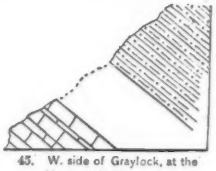
Section 42. In Washington, near Ashley Lake, quartzyte and mica schist in contact, with like dip.

42. Ashley Lake, Washington.

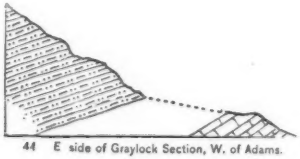
Section 43. At the north foot of South Mountain, south of Pittsfield, near the road, where there has been quarrying. The westward dip indicates the synclinal structure of the mountain.

Section 32 (page 402) represents well also a section at the southwest base of Sugar Loaf Mountain in New Ashford.

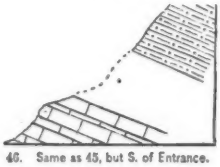
Sections 44–48. These sections in Adams, North Adams and Williamstown bear on the question as to the synclinal structure of Greylock. Section 44 represents the limestone



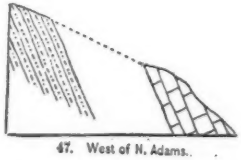
45. W. side of Graylock, at the Hopper, Williamstown.



44 E side of Graylock Section, W. of Adams.



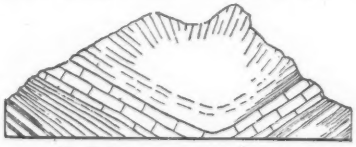
46. Same as 45, but S. of Entrance.



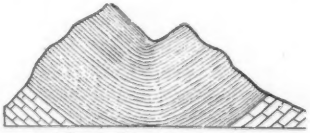
47. West of N. Adams.

and schist at the *east* base of Greylock, in Adams, showing the westward direction of dip and its small angle, sustaining the observations of Prof. Emmons and Prof. E. Hitchcock.

Sections 45, 46 are from the western base of the Greylock Mountains, in Williamstown, at the entrance to the Hopper,



48. Saddle Mountain Section, Emmons.



48.A Greylock Section after Hitchcock.

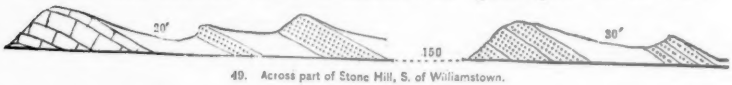
and also agree with Emmons. From these and other observations, Emmons's section, copied in section 48, was made. Farther west, in the southern part of Williamstown, the strike becomes

nearly east-and-west, and the dip southward; but this is true also of the schist, so that the conformability continues. This is true also to the north, as the T-shaped symbols on the map point out.

Abreast of North Adams, the dip of the limestone and schist is as given in section 48, the dip being eastward; and between this point and the locality of section 44, the dip varies to vertical and thence to westward as in that section. The facts make Greylock a broad tray-like synclinal at the south.

The synclinal character of the Greylock mass is manifest also from its high limestone basement which it has on both sides (except for half a mile, in the line of the range, between N. Adams and Williamstown), that is all the way from south of the Hopper, northward to within a short distance of the Notch road, nearly south of Braytonville; and then abreast of Adams for about three miles, the limestone has this great height above the valley, like a high substructure of 400 to 500 feet; southeast of Blackinton, by aneroid nearly 500 feet. The lower 400 to 500 feet of the Hoosac valley consequently were cut down through limestone. The upper limit of the limestone is, consequently, about 1150 feet above the sea-level; and this is nearly one-third of the whole altitude of Greylock—3,505 feet. The high limestone basement of Greylock in N. W. Massachusetts has its counterpart in the similar high basement of Mt. Washington in S. W. Massachusetts, and that of Mt. Anthony in Bennington, Vt.

Section 49 crosses the road on Stone Hill, Williamstown, where the limestone and quartzyte outcrop together. The limestone, quartzyte (the chief rock of the hill) and the black siliceous slate conform in angle of dip along the surface with only short intervals between the outcrops. Whether there is a fault or not between the limestone and quartzyte I found no



49. Across part of Stone Hill, S. of Williamstown.

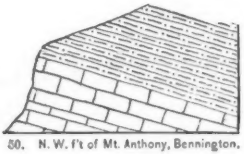
section for determining. Deer Hill, south of Stone Hill, consists of arenaceous or quartzytic mica schist. Bald Mountain, between Williamstown and Clarkesburgh, is of quartzyte with some schist, as described by Emmons; and a prolongation of it appears to extend south of Braytonville into the north end of the Greylock mass, along the ascending road (but chiefly on its eastern side) for a mile.*

Section 50. At the northwest base of Mt. Anthony, in Bennington, Vermont. At the eastern base I found the limestone and schist to dip westward corresponding in position

* The letter Q, which should be here on the map, is by oversight omitted.

very nearly with that of section 44 (Eastern Greylock). The synclinal character of the mountain, which is here sustained by my observations, was determined by the Vermont Geological Survey, one of whose sections passes through the mountain. An unpublished section by Prof. James Hall, made "about 1845," first described in 1854 (in this Journal, an engraved plate containing this among its sections having been sent by Mr. Hall to the writer) shows similar dips on the two sides. Mt. Anthony is, like Greylock and Mt. Washington, one of the more elevated summits of the Taconic range, the height being 2,606 feet. Mr. Hall's plate of sections also includes one of Mt. Washington, and sustains the synclinal character of this mountain. It is a further interesting fact that Mt. Anthony has on its north and east sides a similar high limestone basement; its height is about 400 feet by estimate above the valley at its east base.

51. Berlin, N. Y., East of river.



50. N. W. f't of Mt. Anthony, Bennington.

Section 51. The locality of this section is in Berlin at the west side of the Taconic range; it shows the slate and limestone in alternations at their junction, with the bedding somewhat contorted. The section conforms to all sections on the west side of the Taconic range in its eastward dip, and may be taken, with that at the western base of Mt. Washington, as a representative section. Other sections might be added from my note book from all parts of Berkshire; but the T-shaped symbols over the map make further additions unnecessary.

4. *Stratigraphic Conclusions.*

1. *Taconic schists and the limestone in the western half of the limestone region.*—From the sections through the higher points of the Taconic Mountains, Mt. Anthony, Greylock and Mt. Washington, the following conclusions are deduced.

(1.) The flexures in these three parts of the Taconic range are synclinal.

(2.) The limestone is the underlying rock.

(3.) The limestone lying along the eastern and the western sides of the range are continuous underneath the mountains and therefore one in mass,—a fact already proved for the western limestones and the eastern, by their continuity of mass at the surface. It follows, consequently, that—

(4.) The limestone must be the underlying rock in general, for the lower and narrower portions of the Taconic range—the schists of which are the same in kind and essentially continuous.

(5.) The above conclusions are, for like reasons, true for Tom Ball, Lenox Mountain, South Mountain and other minor ridges east of the main Taconic range in the western half of the Housatonic Valley, but not certainly of all. The hydromica schists and mica schists of these mountains are hence, for the most part, younger than the limestones.

2. *The quartzyte, quartzytic mica schists and limestones of the eastern half of the limestone region.*—In the *eastern* half of the Housatonic Valley, besides true or normal mica schist, there are, in alternating strata, as has been shown, arenaceous (quartzytic) mica schists, massive and bedded quartzytes, thinly bedded micaceous quartzytes, quartzytic gneiss or gneissic quartzyte. In the various sections that have been described, these rocks are shown to be conformable with one another and with the limestone; and this is the universal fact. Faults may occur besides those noted, and many of them not now exposed to view; but the conformability is a fact whatever their number.

With reference to these rocks, the question as to which is normally the underlying formation, the limestone or the schists with the associated quartzyte, is a different one from that above answered, and one not admitting in all cases of so positive an answer.

Some have an opinion ready in advance of investigation, knowing that typical Potsdam is sandstone or quartzyte, and assuming that the reverse is true,—that quartzyte is Potsdam positively. But such assumptions leave the question still for investigation since sand beds belong to all ages and times; and, further, with special pertinence here, they occur as an important part of the Hudson River formation in eastern New York at Chatham (Columbia County) and in other regions. The quartzytes graduate into mica schists; and so the sandstones of the Hudson River formation graduate into shales. Besides, the schists of the Taconic hills pass by gentle gradations eastward into the arenaceous mica schist and quartzyte, as explained for southern Berkshire and the adjoining towns of Connecticut, on page 437 of vol. xxix, 1885.

Many of the sections seem to leave little room for questioning the overlying position and Hudson River age of the quartzyte. In former papers,* I have presented, as evidence on this point, facts like those of sections 22 and 23, from opposite sides of the Konkaput Valley (see map); the rocks being there alike in kind, in stratigraphical relations, in small dip, but opposite in

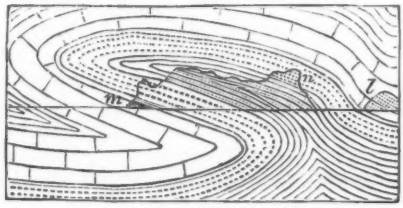
* This Journal, III, v, 33, 1873, and xiii, 45, 1877.

direction of dip, and all in harmony with the idea of an anticlinal (northward in dip of axis) spanning the valley, with limestone as the inferior rock. Farther north a section crossing the same valley continued across Monument Mountain (p. 402) presents a closely parallel case, leading to the same view of the stratigraphic relations. The quartzyte of the east end of the anticlinal over the valley covers the western flank of Bear Mountain from Devany's quarry nearly to Stockbridge.

Studying the facts connected with some of the other quartzytic ridges *within the limestone area* with an equal readiness for either conclusion under consideration, it is difficult to avoid the conclusion that the limestone is the older formation.

But doubts are introduced—not by the idea that Potsdam is sandstone or quartzyte and sandstone or quartzyte is Potsdam, but by the Berkshire fact that *some* of the quartzyte is unquestionably Potsdam or Cambrian. This appears to be true of the quartzyte of Bald Mountain between northern Williamstown and Clarksburg, as inferred from its position with reference to the Archæan mountain just eastward, and its connection with the great eastern range of quartzyte in Vermont. It is true of that of southeastern Pittsfield, eastern Lenox, eastern Lee, eastern Tyringham, in which cases Archæan rocks are near by, a little to the eastward, and the quartzyte usually dips westward toward the limestone as if passing underneath it, and at one locality has been observed to pass beneath it.

In the case of the quartzyte over the west slope and base of Bear Mountain, referred to above, the fact that Archæan probably makes the higher part of this mountain* is good reason for reconsidering the conclusion which has been drawn, and ques-



tioning whether the fold in Monument Mountain is not the reverse of that on page 403, as here figured. The question has

* In my paper of 1873, in vol. v of this Journal, p. 367, and vi, p. 263, I describe a garnet rock consisting of garnet, quartz and some hornblende, as occurring near the summit of Bear Mountain; and as I have not found any similar rock elsewhere in the limestone series, and its aspect is Archæan, I have now little doubt of its Archæan relations. The loose mass of chondroditic limestone found on the south margin of the high region, as reported in the same paper, I believe to be further evidence for the same conclusion.

its two (or more) sides, and can be settled in this and other cases, only after a careful consideration of all the stratigraphic facts.

The quartzyte of Stone Hill and the quartzytic mica schist of Deer Hill, in Williamstown, may be either of the upper or lower quartzyte formation, if judged only by the facts the hill presents. But the position of these areas, in the Williamstown valley, between high ridges of hydromica schist suggest rather that it is the underlying Cambrian; and this is to be inferred also from the quartzyte spur of the Bennington range reaching toward it from the borders of Pownal.

The northern end of the Greylock range has an area of quartzyte as a continuation of that of Bald Mountain, as stated on page 406; and the mica schist near this quartzyte north and east of it may be Cambrian, as well as the quartzyte. The mica schist has much resemblance to that of the western part of Hoosac Mountain; and whatever the fact about the former, there is some reason for making Hoosac Mountain Cambrian. In its western part the mica schist is highly arenaceous, like much of the mica schist of the Quartzyte formation, and it is scarcely less destructible. I know of no evidence from my own observations, or from published accounts, that proves it to be Archæan. Prof. E. Hitchcock long since supposed a fault to separate it from the limestone formation of Adams; but the fault has not been proved to exist, and, if existing, it is no necessary evidence of true unconformability. Farther south, between the quartzyte of Cheshire and central Savoy (see map), the mica schist is probably, like the quartzyte, Cambrian.

This subject will be considered again in a following part of this memoir treating of the Lower Quartzyte formation.

5. *Conclusion as to the age of the Taconic Rocks.*

When the paper on southern Berkshire was published two years since, the evidence as to the age of the Taconic limestone and schists consisted in the occurrence of fossils in the eastern belt of limestone in Vermont, near Rutland and farther north, and in the western limestone and schists of Dutchess County, N. Y., near Poughkeepsie and elsewhere. Since then, as already reported in this Journal,* the discovery of Lower Silurian fossils in Canaan, N. York, has given additional proof from the limestone at the western base of the main Taconic Range —the localities found occurring within one to two miles of the schists of the range, and but ten miles west of Pittsfield, Mass. Professor W. B. Dwight joined me in the search there for fossils, but did all the finding. The first account of them, by

* Vol. xxxi, 241, 248, 1886.

Mr. S. W. Ford and himself appeared in this Journal for April, 1886,* and announced the existence of crinoidal joints, and probably a species of *Cleiocrinus*, of *Pleurotomaria*, and *Murchisonia;* and made the age to be probably, or perhaps, Trenton. The localities then known are the two more southern of the four marked by *o* in a circle on the map, the northern of these two being that at the railroad tunnel where the most of the specimens were obtained. At the meeting of the American Association in last August, Professor Dwight made known other fossils from a locality two miles north of the tunnel, at Mr. Hemmingway's, including species near *Ophileta*, one to nearly two inches in diameter, others related to *Holopea*, and numerous small crinoidal disks. Since then he has discovered, in the limestone 500 yards farther north (on the property of Prof. Drown) still other kinds, including a *brachiopod*, a *Lituites*, or related form, an inch and a quarter across, and *Orthocerata* nearly a foot long and two inches in diameter, remarkable for the closeness of their septa, with also Trilobites resembling the *Bathyuri*, and other kinds not yet determined. He has the fossils under investigation and will report on them before long. The age of the fossils at the last mentioned locality, he regards as either Calciferous or Chazy.

Whatever doubt may exist as to the particular periods to which the species collected should be referred, it is beyond doubt that all are Lower Silurian in age. Other fossils which are decisively Trenton in age, I have reported as occurring in loose masses of limestone in Canaan on the farm of Mr. E. S. Hall, not a mile from the schist of the Taconic range.† The masses consist largely of the minutely columnar coral, *Solenopora*, which occurs in small nodule-like forms and makes a limestone that looks like a limestone conglomerate. Along with this coral, occur crinoidal stems and other small fossils. The rock is nearly identical in species, and in aspect, with the Solenopora limestone found far to the southwest at Pleasant Valley, within eight miles of Poughkeepsie, and described by Professor Dwight. The loose masses are not worn, and this favors the view that they are from some underground ledge to the northward or northwestward, although none just like it occurs there in sight. Mr. Dwight in searching for an outcrop of such a Solenopora limestone in Canaan, found similar nodules in some of the limestone, but they failed of the columnar structure, and he is of the opinion, that the failure is due to incipient metamorphism; which is very probably the fact; for the first trace of metamorphic change would obliterate columns only 1-500th of an inch in diameter; and specimens thus changed he has found to be common near Poughkeepsie.

* Ibid., p. 248.

† This Journal, xxxi, 241, 1886.

Adding the discoveries in Canaan (Columbia County, New York), on the western side of the Taconic Range, to those of Vermont on the eastern side, and in Dutchess County to the south, the facts are enough to demonstrate the Lower Silurian age of the Taconic limestone, the eastern and western. A Cambrian limestone is in places included in the formation, and when so it is conformably to the other strata except where faults occur. Mr. Wing announced the limestone of Vermont to be a combination of limestones from Potsdam to Trenton inclusive; and Prof. Dwight has found the same to be true near Poughkeepsie.

I have not felt at liberty to adduce as additional evidence to that from the Canaan limestone, the discovery of Lower Silurian fossils in the "Sparry" limestone of Hoosac, thirty miles north of Canaan, which Prof. Hall stated, at the meeting of the American Association in 1885,* that he made more than forty years since, because Prof. Hall has never mentioned this discovery in any of his published writings, and has not yet announced the kinds of species or the particular locality. Science cannot rightly use the facts before these details are made known. The existence of fossils in the Hoosac limestone is not at all improbable.

[To be continued.]

The Views of Prof. Emmons on the Taconic System.

The announcement has been very recently made that Prof. Emmons admitted that the age of the western (Sparry) Taconic limestone was Lower Silurian in his second report on the Taconic System, that of 1844:—issued first in a quarto pamphlet, and in 1846 incorporated with his Report on the Agriculture of New York. Since my writings on the subject will need some correction in case this is a right interpretation of his report, I have been again over his statements, and give here the result.

The announcement appears in a paper by Dr. T. Sterry Hunt, in the February number (pp. 114–125) of the American Naturalist (issued near the close of March).† It is stated that Prof. Emmons in 1842, in his first detailed publication on the Taconic system (Report on the Geology of New York, 1842), pronounced the Transition or Sparry limestone, like the rest of the Taconic, to be older than the lowest member of the New York Lower Silurian (or Champlain Division), but that in 1844, 1846, "he made one important and significant change," "acquiescing in the judgment of Eaton" ['of 1832'] he "now declared that the upper portion of the Taconic system—namely, the great belt of slates with limestones, sandstones and conglomerates—designated by him in 1842 as the Taconic slate, and including both the Transition Greywacke and

* This Journal. III, xxxi, 248, 1886.

† The title of the paper is, "The Taconic Question Restated."

the Sparry lime-rock of Eaton, was the stratigraphical equivalent of the lower part of the Champlain division, and in fact a thickened and modified form of the Calciferous sandrock, which was now said to be in its eastern extension 'protean' in its character and to include a great variety of rocks." Besides this, we find also in the same paper, the idea that Professor Emmons "came forward in 1842 as the champion of the views of Eaton," and this idea is repeated afterward in other championing words in which the first correct announcement of the age of the Taconic System is traced to Eaton.

Since it is established, by the facts already presented in this memoir, that Emmons's Sparry or western limestone, and his Stockbridge limestone (the eastern) are one in mass, any argument sustaining the Calciferous age of the Sparry limestone sustains the same for the Stockbridge limestone. But that Professor Emmons suggested the Calciferous as the age of either of these limestones, or of the "Taconic slate," in his memoir of 1844 and 1846, or was a "champion of the views of Eaton," I have been able to find no proof.

The "Champion of the views of Eaton," Professor Emmons, has these three sentences relating to Professor Eaton in his Report on the Geology of New York (1842).

On page 19, speaking of previous geological work in northern New York, he says: "Previous to the year 1837, nothing exact was known of the geology of the northern district. Mr. Eaton, who was the oldest laborer in geology in New York, had not extended his observations far into this field. He had, however, represented the McCombe Mountains as composed of ranges of gneiss, extending from the valley of the Mohawk to the Provincial line, and the intermediate valleys, of limestone extending along their bases and around their northern extremities; and the whole section as being composed of two principal formations, a Carboniferous slate, denominated Primary, and a calcareous formation, denominated Secondary. It is sufficiently evident that all this was imaginary; it is even difficult to conceive how imagination could have carried even a partial observer so far from the truth."*

Two lines below, on the same page, we have: "In this paper [by Mr. Finch] there is a brief account of the rocks of this county [St. Lawrence]; the Potsdam sandstone was spoken of as a Transition rock, and the Calciferous sand-rock of Eaton as a siliceous limestone."

On p. 280: "The mass of grit is the greywacke of authors; some portions are brecciated, or belong to that variety denominated *rubble* by the late Professor Eaton."

* In this Journal, III, xix, 270, 1880, Dr. Hunt says that the lithological characters of the primary gneissic formation of northern New York "were clearly defined by Eaton, who under the name of the Macomb Mountains, described what have since been called the Adirondacks," etc.

These are all the sentences in the volume that contain the name of Eaton or relate to his views.

Professor Emmons, on the second page of his chapter VII on the TACONIC SYSTEM, has the heading, "*Persons who have Contributed to our Knowledge of the Taconic rocks*," and under it the "champion of the views of Eaton," should of course have something about the views of Eaton. The first two paragraphs are as follows:

Page 136. "By reference to the early numbers of the Journal of Science, it will be seen that Profs. Dewey and Hitchcock early turned their attention to the rocks under consideration. The former, distinguished for his scientific attainments, gave an elaborate essay, wherein the rocks were described as fully as was possible in the infancy of geology in this country; in fact, so far as mere description is concerned, very little remains to be added. In 1829, the history of Berkshire was published, the matter of which was contributed by the clergymen of the several parishes in the county. In this work an abridgment of Professor Dewey's former essay appeared, so that a general account of these rocks has been widely circulated. Prof. Hitchcock has at various times furnished many important facts in regard to the geology of Berkshire, but, as appears from his publications, has relied mainly upon the information derived from Professor Dewey's labors, especially in his elaborate and excellent work on the rocks of Massachusetts.* To these gentlemen, therefore, we are principally indebted for the facts which have been placed before the public."

Page 125. "The limestones of Berkshire have been fully and ably treated of by Professors Dewey and Hitchcock."

Page 151. Speaking of the Sparry limestone, he says: "This limestone is called Transition limestone upon the geological map contributed by Professor Dewey for illustrating the geology of Berkshire county, Massachusetts."†

In this mention of early workers, there is not a word about Eaton anywhere. Dewey made his investigations eight to fifteen years before Professor Eaton's work of 1832 was published. Eaton made no observations on the Taconic rocks, and honorably gave credit for all he knew (see page 270 of this volume) to Prof. Dewey. According to the facts, consequently, "the persistent war waged" against "the views of Amos Eaton" (p. 121 of the Naturalist) —till now an unheard of war—was begun by his pupil, Professor Emmons. Eaton was a man of great energy and enthusiasm; but his was the beginning-time in American geology; and little credit is to be given either to him or to Dewey for their adoption of the term Transition from European writers, or for any ideas on the age of the rocks.

Professor Emmons is charged (on p. 120 of the paper and be-

* These remarks with reference to Professor Hitchcock relate evidently to his earlier report, that of 1835, on the Geology of Massachusetts, and not to his later quarto report of 1841.

† This Journal, vol. viii, 1824. Emmons dedicates his "American Geology" to Dr. Dewey.

yond) with "contradictions" and "perplexing discrepancies" in his volume of 1842; and in a note at the bottom of the page, "pages 121, 124, 125, 280–282, and further, p. 147," are referred to for testimony on this point. Only one of these pages is in the chapter on the Taconic system—the "and further p. 147." I find no "contradictions" or "perplexing discrepancies" in that chapter, or in anything relating to the Taconic system.

Professor Emmons does not merit the condemnation thus made; for he is clear and consistent throughout.

As to the change of opinion asserted, I find, as I had done before, that in 1842, Professor Emmons, contrary to the idea conveyed on page 123 of the paper in the Naturalist, made the Sparry or western limestone *older* than the Stockbridge limestone, because the western dipped eastward beneath it; he commences his paragraph on the subject of relative age (Rep. Geol. N. Y., "and further, p. 147,") with the sentence "there seems to be no valid reason against the opinion that the most western belt of limestone is, after all, the oldest of the Taconic limestones."

In 1844, 1846, speaking, in his Memoir, of the Taconic rocks, he says, p. 63 of the Agricultural Report and 19 of the 1844 pamphlet): "I shall describe the rocks in the *descending order*," and this is the order:

First. "The BLACK SLATE" (on pp. 63–65), described as affording at Bald Mountain, Trilobites.

Second: "The TACONIC SLATE WITH ITS SUBORDINATE BEDS" (on pp. 65–72); of which he says: "Occupies almost the whole of Columbia, Rensselaer and Washington Counties" (p. 72); "extends from Lansingburgh to the Sparry limestone in the eastern part of Hoosic near the western bounds of Bennington in Vermont—at least 20 miles in a direct line" (p. 72); "It crosses the [Hudson] river near Poughkeepsie, ranging southward so as to underlie the belt of country to the west of Newburgh for six or eight miles" (p. 103). In these and other statements he gives the Taconic slate a wide range, and includes under it slates near Poughkeepsie that in recent years have afforded Hudson River brachiopods. He makes it older than the Black Slate.

Third: The "SPARRY LIMESTONE (on pp. 72–74): of which he says, "Occupies the belt of country comprising the eastern part of Dutchess, Columbia, Rensselaer and Washington counties (p. 73); "not far west of the dividing line between Massachusetts, Vermont [on the east side] and New York [on the west]" (p. 74); "through Ancram, Hillsdale, Canaan, New Lebanon, Berlin, Petersburgh, Hoosic, Whitecreek," etc. (p. 74). In the account of this limestone I find nowhere, any more than in that of the Taconic slate, the slightest intimation of a change in his opinion as to its age. All the rocks of the Taconic series are made unequivocally older than the Potsdam sandstone.

As above indicated, Professor Emmons did make one change in 1844, and a wise one. In 1842 he argued from the eastward dip, as I have shown, that the Sparry limestone was the oldest of the

Taconic limestones. In 1844, 1846, he dropped the argument and the conclusion, and showed, by sections, how through flexures the order of original superposition might be reversed. This change left the Sparry limestone and Taconic slate older, as before, than the Potsdam. Further, he added the Black slate of Washington Co., N. Y., with its trilobites, and made this the *upper* or newer member of the series, on account of the fossils, with the other members following in the descending order above given,—the quartzyte at the bottom.

Professor Emmons was right in his Berkshire stratigraphical observations. He drew chronological conclusions on data that we now know to be too uncertain for any safe inference, and on lithological data extended his system beyond its true limits; but in those decisions at that early time there is nothing to his discredit, while his investigations are greatly to his honor.

It is a fact of historical importance in the Taconic controversy, that the writings, on the subject, by Professor Mather, the Professors Rogers, Dr. D. D. Owen and Professor E. Hitchcock, the early questioners or opponents of the Taconic system, do not contain a discourteous word. Their criticisms are such as give life and progress to the science. Professor James Hall, whatever opinions he may have had or may have orally expressed, has nowhere in his notes on the fossils of the Taconic slate (Black slate), an offensive remark; and these are all of his writings on the subject. Logan, after the Quebec discoveries of the Canada survey, put a few lines in his Canada Report—a very few, in all not over twenty; he did it courteously and not even controversially. He afterward made examinations in Vermont, Massachusetts and New York which gave him confirmatory conclusions, but personally he wrote nothing on these conclusions.

The writer's acquaintance with the subject began in 1843, after an absence abroad of four years; and for many years afterward he was learning, but published nothing. After the discoveries of fossils in Canada, and the announcements of the Canada Geological Survey, I adopted Logan's opinion; and this is presented in my Manual of Geology, published first in 1863. It appeared at the time to be the generally accepted opinion. My investigations in Berkshire were commenced in July of 1871, in order to get at the truth, without any feeling of opposition to Professor Emmons.

Dr. T. Sterry Hunt was one of the strong and active opponents of the Taconic system between the years 1849 and 1875. The Report of the American Association for 1850 has his decision that "The results of the [Canada] survey have shown, as I had the honor to state at the last annual meeting at Cambridge [in 1849], that the Green Mountain rocks are nothing else than the rocks of the Hudson River Group with the Shawangunk conglomerates, in a metamorphic condition;" and in his address before the same Association for 1871, he stated, as he had done many times in the interval, that the conclusion of Rogers and

Mather, referring the Taconic System to the "Champlain Division" of the New York rocks had been sustained by subsequent observations. Further, his "Chemical and Geological Essays" published in 1875 (see Title-page) contains the Association address of 1871, and the same remarks on the Taconic. Here are *twenty-five years* of opposition to Professor Emmons, in a number of papers, and never once a hint that Emmons agreed with him in the Calciferous age of either of the rocks. The account of the investigations of Logan and Hall in Dutchess County, New York and elsewhere, bearing against the Taconic system, as published in this Journal for 1865, has attached to it Dr. Hunt's name as he was the writer. Dr. Hunt's opinions were not always couched in courteous language. In 1861, he makes the Taconic, exclusive of the slates, equivalent of the Calciferous, adding: "It remains to be seen whether Dr. Emmons can retain, from the wreck of his system, the lower slates as a Taconic formation older than the Potsdam." This sounds like "persecution;" and the series of papers like "persistent war waged against Ebenezer Emmons." Now, the Restatement indicates for its author a return to the idea of the Calciferous age of some of the Taconic rocks.*

* The continuation of the "Taconic Question Restated," to be found in the March number of the Naturalist (pp. 238–250), has been published since the above was put in type—the number having been received at New Haven April 13th. It calls for no further remarks. But as it will aid in clearing away doubts, and give a fuller view as to what have been, as the author expresses it (p. 248), "my own teachings," I cite a few more sentences from his papers during the 25-year period of *opposition*, and others from two of those of the subsequent period of *agreement*.

Review of the Progress of American Geology, in this Journal, II, xxxi, 402, 1861. "The Quebec group with its underlying shales is no other than the Taconic system of Emmons.

"*Review of Mr. Barrande, On the Primoridial Zone in North America*," in the Canadian Naturalist, 1861, and this Journal, II, xxxii, 427, 1861. "Dr. Emmons claims that the whole of his Taconic system is inferior to the Potsdam sandstone, which is the admitted base of the Champlain division, but we have already shown that the whole of his system, with the probable exception of these slates [the black slates] is of the age of the Calciferous sandrock, the second member of that division." "The fossils of the Quebec group show it to be the paleontological equivalent of the Calciferous sandrock. The Stockbridge and Sparry limestones with their accompanying slates (excepting only 7 and 8 [the Taconic slate and black slate]), we conceive to be no other than the Quebec group."

Address to the American Association, August. 1871. Salem, 1871.—p. 15, "The Taconic system, as defined by him [Emmons] may be briefly described as a series of uncrystalline fossiliferous sediments reposing unconformably on the crystalline schists of the Green Mountains, and partly made up of their ruins; while it is, at the same time *overlaid unconformably by the* Potsdam and Calciferous formations of the Champlain division, and constitutes the true base of the paleozoic column,—thus occupying the position of the British Cambrian." Hence in 1871 the author had not made the discovery that Professor Emmons referred any part of his Taconic system to the Calciferous.

History of the Names Cambrian and Silurian in Geology; published in the Canadian Naturalist, for April and July, 1872.—p. 36, "Emmons, misled by stratigraphical and lithological considerations, complicated the question in a singular manner, which scarcely finds a parallel except in the history of Murchison's Silu-

In view of these twenty-five years of opposition, and of present indications, it is of interest to read again (if already once read) the pathetic remark on page 122 of the paper in the Naturalist.

"There is a painful resemblance in many respects between the story of Emmons and of his opponents and that of the warfare waged against Sedgwick by Murchison and his allies in the famous Cambrian and Silurian controversy, as set forth by the present writer in 1874 in his Chemical and Geological Essays (pp. 364, 365):" the same volume that contains Dr. Hunt's Association Address.

A note to "opponents" in this sentence states a further incident in the "persecution" from a letter by Professor Emmons, in which Professor Emmons says, that "the *editor of the American Journal of Science* refused to publish my remarks upon Logan's Report when he [Logan] announced his Huronian System, though their tenor was courteous in the extreme; I claimed that the Huronian was only the Taconic System." The refusal was on the ground that the "remarks" contained no facts sustaining the opinion, and that opinions on such a point without facts were of no value to the science. The Huronian region and the Taconic were remote from one another, and Logan's discoveries of fossils in Canada seemed to be too decisive to be so set aside.

But this instance of "persecution" occurred far back in that

rian sections. Completely inverting, as I have elsewhere shown, the order of succession in his Taconic system, estimated by him at 30,000 feet, he placed near the base of the lower division of the system, the Stockbridge or Eolian limestone, including the white marbles of Vermont, which by their organic remains have since been by Billings found to belong to the Levis formation [Quebec group].

The following are those on *the other side.*

On the Azoic Rocks of Southeastern Pennsylvania. Report E. of Geol. Survey 1878, pp. 206, 207. "We have given reasons for regarding the Lower Taconic, or the Primal and Auroral strata of the great Appalachian Valley as the equivalents of the similar series in southern N. Brunswick and of the Hastings series in Ontario with its Scolithus and Eozoon. While it has been shown, in a preceding chapter, that the Upper Taconic includes the organic remains of the European Cambrian at least as low as the Menevian, it is by no means certain whether the Lower Taconic series is to be regarded as the equivalent of the still lower beds of the Cambrian of Great Britain and Sweden. In this uncertainty it is deemed well to preserve for this series the original name of Taconic."

"*The Taconic Question.*" 84 pp. 4to, published in the volumes of the Transactions of the Royal Society of Canada for 1883 and 1884. In the "conclusions" the author says (pp. 149, 150): "There exists in eastern North America a great group of stratified rocks, consisting of quartzytes, limestones, argillites and soft crystalline schists, which have altogether a thickness of 4000 feet or more, and are found resting unconformably upon various more ancient crystalline rocks from the Laurentian to the Montalban inclusive. This series called Transition by Maclure . . . . is the Lower Taconic of Emmons." This series which I have preferred to call Taconian is essentially one of Transition crystalline rocks."—p. 151, "The Taconian, as I have suggested, may constitute a link between the older Eozoic groups and those of Paleozoic time."—p. 151, "the Upper Taconic group, the First Graywacke of Eaton, the Potsdam and Quebec groups of Logan (which include a large part of what was described by Mather and by Logan as Hudson River group) we have seen to be the Appalachian representative of the Cambrian group."

If any one doubts whether the author of the preceding extracts and of the article in the Naturalist is one and the same person he must investigate for himself.

interval of twenty-five years during which Dr. Hunt was one of the persecutors if there were any such—an interval, moreover, which was continued, without any abatement in the opposition on Dr. Hunt's part, for twelve years after Professor Emmons's decease.

I think I have stated facts enough to end the Taconic controversy. The work which Professor Emmons did in the stratigraphical geology of the Taconic region and his discoveries in Paleontology will in the main stand; while no effort can keep life in wrong conclusions, whatever the source.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the generation of Chlorine gas in Kipp's apparatus.*—The use of bromine in the laboratory would appear to be due in many cases to the inconveniences attending the ready preparation of the more active chlorine. Winkler has sought to render the preparation of chlorine easier by suitably modifying the ordinary process of obtaining this gas from chloride of lime and hydrochloric acid. For this purpose the chloride of lime is mixed with about a fourth of its weight of calcined gypsum, and then so moistened with cold water as to form a crumbly semi-coherent mass. It is stirred in a mortar until entirely homogeneous and then is beaten with an iron mallet into a square iron frame ten or twelve millimeters thick, resting on an iron plate. When full the sides are covered with wax-cloth and the whole is submitted to the action of a strong press. The square cake thus obtained is then cut into smaller squares and dried at a temperature not exceeding 20°. The cubes thus obtained should be preserved in a well-closed vessel. When used they are placed in a well-made Kipp's gas-evolution apparatus, with hydrochloric acid of 1·124 specific gravity previously diluted with an equal volume of water. The preparation of chlorine in this way is as convenient and its evolution as constant as that of carbon dioxide by the use of marble. The author announces that Trommsdorff has agreed to keep these cubes already made, on hand for sale.—*Ber. Berl. Chem. Ges.*, xx, 184–5, Feb. 1887. G. F. B.

2. *On the action of Kaolin on the alkali-chlorides.*—In studying the action of kaolin on the halogen compounds of the alkalies, Gorgeu has shown that when this substance is calcined with these compounds, double neutral silicates are formed, which themselves in some cases form direct combinations with the halogen salts. The sodium-aluminum silicate thus formed unites directly with sodium iodide to form a well crystallized compound. When the kaolin is calcined with sodium or potassium chloride,

hydrogen chloride gas is disengaged in abundance at a red heat; and if the action be continued in presence of water vapor, a considerable proportion of the chloride will be decomposed, depending on the amount of alumina in the kaolin. Bromides under these conditions evolve hydrogen bromide; but iodides evolve iodine, the hydrogen iodide being broken up by the heat. If the kaolin is anhydrous and the calcination is effected in a current of dry air, chlorine, bromine and iodine are evolved, but the action is much slower. By using kaolins free from carbonates, by mixing them thoroughly with the quantity of salt that they can completely decompose and by carrying the mixture in half an hour to a cherry-red and maintaining it there for three-quarters of an hour in a current of steam, 97 per cent of the chloride may be decomposed, yielding hydrogen chloride. With absolutely dry materials, heated in dry air to a bright cherry-red, about one-half of the chlorine contained in the salts is obtained free.—*Ann. Chim. Phys.*, VI, x, 145–170, Feb. 1887. G. F. B.

3. *On the Distribution in the Soil of the nitrifying organisms.*—In a paper published some years ago, WARINGTON gave an account of the experiments which he made at Rothamsted to ascertain to what depth the presence of the nitrifying organisms could be detected in the soil. From three series of experiments embracing 28 trials he concluded that "in our clay soils the nitrifying organism is not uniformly distributed much below 9 inches from the surface." Subsequently, further experiments in this direction were made, essentially similar to the others except that rather more soil was placed in the solution to be nitrified and to this solution a decigram of gypsum was added to each liter. The results were now in many respects entirely different. Not only was the process of nitrification more speedy but soil from very considerable depths was found capable of starting it. Soil from a fallow plot had this property uniformly to a depth of 2 feet and in some cases to 3 and even 4 feet. Soil from a white clover plot was all effective down to 3 feet, and one sample at 4 feet and one at 6 feet were found to be so. The lucerne plot produced nitrification with all samples down to 4 feet and one sample at 6 feet was active. A third series of experiments was made a year later, to see if these results could be due to the contamination of the solutions in the field by soil-dust from the surface. But the results confirmed those already obtained. No failure to produce nitrification was observed in samples of soil down to and including a depth of two feet from the surface. At 3 feet only one sample out of eleven failed. At 6 feet one-half the trials failed; and at 7 and 8 feet all failed. The failure in the earlier experiments was due the author thinks to the absence of gypsum from the test solutions. The final conclusion, therefore, is that the nitrifying organisms are practically confined to the surface soil; for although they may occur at considerable depths in a loam or clay subsoil, they occur there in small quantity and in feeble condition.—*J. Chem. Soc.*, li, 118, Feb. 1887. G. F. B.

4. *On the Absorption of Gases by Carbon.*—Though experiments have been frequently made to determine the volume of various gases which a unit volume of charcoal absorbs, there seem to have been very few attempts to determine the composition of the gas subsequently given up by the charcoal on heating. BAKER has undertaken some experiments to ascertain the nature of the gas thus given up by charcoal when it has absorbed oxygen. The charcoal examined was that from boxwood and animal charcoal; but as the latter, especially after purification, absorbed a far larger volume of gas it was used by preference. Duplicate experiments were also made; the oxygen being dried in one series and saturated with moisture in the other. The carbon was contained in a cylindrical bulb one-quarter to one-third of an inch in internal diameter, drawn out to the size of a quill at one end. By means of a Sprengel pump the whole was exhausted, the bulb being heated to a high temperature. After cooling, it was attached to a gas pipette, oxygen was allowed to enter and to remain at the normal pressure until the absorption was complete, the bulb meanwhile being immersed in water or in a freezing mixture, at pleasure. The bulb was then exhausted. On heating it now to 100° and exhaustion, the gas obtained from it could be examined. The author finds: 1st, that moist oxygen absorbed at —15° by carbon, is not evolved free or combined at 12°; 2d, that (α) the water-vapor and oxygen thus absorbed, when kept for a week at 100°, produce carbon dioxide, the charcoal giving up 7 times its volume, (β) water vapor and carbon kept at 100° for a week produce no carbon dioxide, and (γ) carbon and dry oxygen at 100° for a week produce no carbon monoxide; 3d, that (α) a temperature of 450° is required to remove the dry oxygen retained by carbon, carbon monoxide being the chief product, (β) the more free from moisture the substances the less the oxidation, and hence (γ) carbon is burned directly to monoxide by the absorbed and firmly retained oxygen.—*J. Ch. Soc.*, li, 249, March 1887. G. F. B.

5. *On the Valence of Bismuth.*—The fact is well known that the organic compounds of the nitrogen group show in their trivalent combinations a greater intensity in the free bonds than the inorganic compounds. Thus while arsenous chloride $AsCl_3$ will not unite with more chlorine, methyl-arsenous chloride CH_3AsCl_2 forms a tetrachloride. MICHAELIS has sought to determine in this way the quinquivalence of bismuth. By adding bromine to a solution of bismuth-methyl in well-cooled petroleum-naphtha, no addition product was obtained. Nor was he able to add ethyl iodide to bismuth-methyl. But bismuth-phenyl thus treated gave at once triphenyl-bismuth dibromide $(C_6H_5)_3BiBr_2$ and chloride $(C_6H_5)_3BiCl_2$, as permanent and well defined compounds. In these bodies we have for the first time compounds in which five univalent atoms or atomic groups are united to a single atom of bismuth; and hence they establish the quinquivalence of bismuth as certainly as they did that of antimony.—*Ber. Berl. Chem. Ges.*, xx, 52, Jan., 1887. G. F. B.

6. *On the Action of Phosphoric chloride on Ethyl acetondicarbonate*.—In the hope of elucidating the constitution of certain unsaturated acids of the fatty series, BURTON and VON PECHMANN have examined the product of the action of phosphoric chloride upon ethyl acetondicarbonate, as well as the two other bodies, acid in character, which are produced from this by the loss of hydrogen chloride. The first product of the above reaction is probably $CO_2C_2H_5.CH_2.CCl_2.CH_2.CO_2C_2H_5$; and this loses HCl spontaneously and becomes $CO_2H.CH.CCl.CH_2.CO_2H$, which because of its formation and analogies the authors call *β*-chlorglutaconic acid. By the further loss of HCl, a new dibasic acid is formed having the formula $C_5H_4O_4$, to which they give the name glutinic acid, and for which the constitutional formula $CO_2H.C{\equiv}C.CH_2.CO_2H$ appears most probable. The former acid is obtained in white crystals fusing at 129° and easily soluble in water. The latter acid crystallizes in white needles and fuses with decomposition at 145°–146°. It is easily soluble in water, alcohol and ether, insoluble in chloroform and in benzene.—*Ber. Berl. Chem. Ges.*, xx, 145, February, 1887. G. F. B.

7. *On the behavior of Iron and Steel under the operation of feeble magnetic forces*.—Lord RAYLEIGH discusses in this paper the question whether iron responds proportionally to feeble magnetic forces. This question is of practical interest in the working of telephonic instruments. The experiments of Ewing apparently prove that the hypothesis of Maxwell that when the molecular magnets of Weber are rotated they undergo first an elastic and then a partially non-elastic deflection, does not represent the actual phenomenon. They suffer instead a "kind of frictional retardation which must be overcome by the magnetizing force before deflection begins at all." The experiments of Rayleigh prove "that in any condition of force and magnetization, the susceptibility to small periodic changes of force is a definite and not very small quantity, independent of the magnitude of the small change. That the value of the susceptibility to small changes of force, is approximately independent of the initial condition as regards force and magnetization, until the region of saturation is approached."

In the course of his investigation the author experimented upon the construction of a sensitive galvanometer with a field strengthened by iron. The system of needles was astatic. The electromagnet was of horseshoe form, with a core of hard Swedish iron wire $3{\cdot}3^{mm}$ in diameter. The electro-magnet was held so as to embrace the upper needle system. The experiments showed that a galvanometer of high sensitiveness could be thus constructed. The tendency to residual magnetism would, however, be troublesome.—*Phil. Mag.*, March, 1887, pp. 225–245. J. T.

8. *Movements of the Wings of Birds, represented according to three dimensional space*.—M. MAREY, in a very interesting article illustrated by figures, represents the results obtained by instantaneous photographs of the flight of birds taken successively as if

the bird were projected on three planes. It is hoped that this new method of study of the flight of birds will add largely to our knowledge of the kinematics of flying."—*Comptes Rendus*, No. 6, Feb. 7, 1887, p. 323. J. T.

9. *Upon the Magnetic effect of Earthquakes.*—At various magnetic observatories on the continent of Europe, slight disturbances were registered which apparently were connected in time with the late earthquakes. M. Mascart believes that a more careful examination of the records of different observations will show the connection which may exist between the two disturbances.—*Comptes Rendus*, No. 10, March 7, 1887, p. 634. J. T.

10. *Heat of the Sun.*—Frölich communicates the second portion of his voluminous paper on the measure of the sun's heat. In the course of the paper he examines Langley's hypothesis that the absorption of heat is proportional to pressure of air, and does not find a suitable agreement between his own observations and records of the barometer. He concludes, therefore, that the hypothesis is not true. The observations show that the heat of the sun is subject to important changes. The question whether an increase of the sun's heat follows a lessening of the sun's spots cannot be decided without a more careful study.—*Annalen der Physik und Chemie*, No. 4, 1887, pp. 582–620. J. T.

II. Geology and Natural History.

1. *Bulletin of the American Museum of Natural History, New York.*—No. 8, of vol. i, issued Dec. 28, contains a notice of investigations on Lower Silurian geology along the eastern shore of Lake Champlain, by Professor M. Seely and Pres. E. Brainerd of Middlebury, Vt., with a description of new fossils by R. P. Whitfield; and, by the same, a notice of a new fossil, probably a sponge related to Dictyophyton, from the slates at Kenwood, near Albany, N. Y.

2. *Brief notices of some recently described Minerals.* Caracolite.—This mineral was investigated by the late Professor Websky of Berlin, but was not announced until November, 1886, shortly after his sudden death. Its characters are as follows: Orthorhombic with pseudohexagonal symmetry due to twinning. The crystals appear as obtuse double hexagonal pyramids with prism, resembling witherite, to which it is also related in its axial relations, viz: $\breve{a} : \bar{b} : c = 0{\cdot}5843 : 1 : 0{\cdot}4213$. The colorless crystals of caracolite are associated with minute bright blue cubes of the rare species percylite, and the material analyzed consisted of a mixture of the two species in about the ratio of 6:1. The composition deduced for pure caracolite is expressed by the formula $PbHClO + Na_2SO_4$, requiring: Pb 51·56, Na 11·46, S 7·97, Cl 8·84, H 0·25, O 19·92=100. The mineral is named from the locality Caracoles, Chili.—*Ber. Ak. Berlin*, p. 1045, Nov., 1886.

Kaliophilite. In an extended article upon the ejected masses from Monte Somma, Mierisch describes a mineral allied to nephe-

lite calling it kaliophilite, the name having reference to its high percentage of potash. It occurs in colorless prismatic or acicular crystals, which do not, however, show sufficient distinctness of form to allow of the system being determined to which they belong. They show basal cleavage, are optically uniaxial with negative double refraction; the specific gravity is 2·602. An analysis afforded:

	SiO_2	Al_2O_3	CaO	K_2O	Na_2O
$\frac{3}{2}$	37·45	32·43	2·18	27·20	2·26=101·52

This corresponds to the formula, $K_2Al_2Si_2O_8$ which is that of an anhydrous muscovite, and is analogous to that of anorthite, nephelite and eucryptite in which calcium, sodium and lithium, respectively, enter in the place of the potassium here present.—*Min. petr. Mitth.*, viii, 160.

HARSTIGITE. Described by G. Flink of Stockholm. It occurs in prismatic orthorhombic crystals with an axial ratio of $\breve{a}:\bar{b}:c=0·7141:1:1·01495$. No cleavage was observed; fracture small conchoidal to splintery; hardness 5·5; specific gravity 3·049; colorless with vitreous luster. An analysis on 0·3 gram yielded:

SiO_2	Al_2O_3	MnO	CaO	MgO	K_2O	Na_2O	H_2O
38·94	10·61	12·81	29·23	3·27	0·35	0·71	3·97=99·89

This does not lead to a satisfactory formula, and the composition must remain somewhat doubtful until more material is obtained for investigation. Obtained at the Harstig mine at Pajsberg, Sweden.—*Bihang Svensk. Vet.-Akad. Handl.*, xii, 1886.

SCHUNGITE. A name given by A. von Inostranzeff to a form of amorphous carbon occurring in the crystalline schists of Schunga in the Olenetz government, Russia. A similar form of carbon from the Saxon Erzgebirge was called graphitoid by Sauer. —*Jahrb. Min.*, 1886, i, 92.

3. *Materialien zur Mineralogie Russlands;* von N. VON KOKSCHAROW. Vol. ix, pp. 273–365. St. Petersburg, 1886.—This part forms the closing portion of the ninth volume of the great work on Russian Mineralogy by von Kokscharow. It contains a supplementary notice of the interesting variety of xanthophyllite called waluewite, giving a more exact determination of the crystalline form than has been obtained hitherto; also an extended review of papers on the topaz of Durango by N. von Kokscharow, Jr., and by DesCloizeaux, with an exhaustive list of calculated angles for the many new forms. A description is also given of the mineral MURSINSKITE, thus far known from two specimens only which were found more than thirty years ago. It occurs in minute crystals inclosed in large transparent topaz crystals from Alabaschka, near Mursinsk in the Ural. The form is that of a tetragonal pyramid with angles of 127° 31′ (terminal) and 77° 22½′ (basal); two pyramids of the second series and several zirconoids were also observed. The color is wine- to honey-yellow, transparent to semi-transpar-

ent; the hardness is six to seven and a determination of the specific gravity gave 4·149; this result has, however, no great claim to accuracy. Nothing is known about the chemical composition, so that its true relations must remain in doubt until additional material is obtained. The rarity of the species will be appreciated from the fact that in the past thirty-two years no additional specimens have been found, though often searched for.

4. *On the relation of Schorlomite to Garnet.*—Dr. KÖNIG has recently published the following analysis of a massive titaniferous garnet from southwestern Colorado:

	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	CO_2	
G.=3·689	30·71	8·11	2·20	22·67	34·29	0·30	1·48	=99·82

This result can be made to conform to the garnet formula only by assuming that part of the titanium replaces the alumina as Ti_2O_3 (3·64 p. c.). This garnet resembles the titaniferous melanites from the Kaiserstuhl described by Knop and the discussion has led König to the same conclusion in regard to schorlomite that Knop and Rammelsberg had reached on the basis of the Kaiserstuhl garnets, viz: that it is essentially a garnet containing Ti_2O_3 as well as TiO_2. An analysis of the Arkansas schorlomite gave König:

	SiO_2	TiO_2	Ti_2O_3	Al_2O_3	Fe_2O_3	CaO	MgO	MnO	
G.=3·876	25·80	12·46	4·44	1·00	23·20	31·40	1·22	0·46	=99·98

This agrees approximately with the garnet formula; the general conclusion seems probably correct.—*Proc. Acad. Nat. Sci. Philad.*, 355, 1886.

III. BOTANY.

BOTANICAL NOTES.—The numbers of this Journal for January, February, and March, 1886, contain an extended paper by Professor Penhallow of Montreal on "*Tendril Movements in Cucurbita maxima and C. Pepo.*" The author has recently sent us a copy of a quarto memoir, separately issued from the Transactions of the Royal Society of Canada, vol. iv, sect. iv, read May 27, 1886, on *Mechanism of movement in Cucurbita, Vitis, and Robinia;* also from the Canadian Record of Science, of Oct., 1886, *Additional notes upon the Tendrils of Cucurbitaceæ.* On looking over these two articles, the larger of which enters somewhat into the history of the subject and cites a good many publications, we find no reference whatever to his own papers published, at the author's particular desire in this Journal. This is the more remarkable as in them Professor Penhallow coins a new term, which he continues to make much use of; and an author generally likes to date his own discoveries as near to their inception as he can. [We learn that the omission was purely accidental, through forgetfulness.]

A Redwood Reserve.—We have received a copy of "An earnest appeal to the enlightened self-interest of California" for the preservation of a Redwood park in the Pescadero district, north of

Santa Cruz. It is earnestly hoped that the appeal which Mr. Ralph Sydney Smith very eloquently and sensibly makes may be successful. If nothing is done to preserve for posterity a specimen of Redwood forest, including, if possible, some of the large trees, future and not far distant generations of Californians will have cause to revile the memory of their forefathers. Time was when we had hoped for a government reservation of such forest, of ten miles square, in the northwestern part of the State, and it would have cost nothing. But the plan now broached, although it will cost something, has the great advantage of fairly securing this object and at the same time giving to San Francisco an unrivaled park quite within the reach of its citizens. Let us hope that the few great Redwoods which survive above Santa Cruz may form an annex to this reservation. Unless something of this kind is speedily done, one of the peculiar glories of the State of California will in the next century be only a tradition.

Notes of a Naturalist in South America, by John Ball, F.R.S., etc., is a duodecimo volume of 417 pages (London, Kegan, Paul & Co.), which we had hoped to give an account of. Especially one would wish to discuss the two appendices, viz: A. On the fall of temperature in ascending to heights above the sea-level, and B. Remarks on Mr. Croll's theory of secular changes of the earth's climate. We can only commend them to the consideration of those interested in terrestrial physics and meteorology.

Pittonia, a Series of Botanical Papers, by Edward L. Greene, Assistant Professor of Botany in the University of California. Vol. i, part 1. Berkeley, California, March, 1887.—An octavo of 48 pages. No preface or announcement is given. We may infer that Pittonia is in reference to the family name of Tournefort, and that the publication may have for its model the Adansonia of Baillon; but the ideas of genera and species are on quite another model. Perhaps the plan may be that of the Linnæa; for, as in that occasional rather than serial publication, a portion of the pages is given to reviews of recent botanical literature. Good botanists have followed Decaisne in referring the Big-roots to *Echinocystis*; but we suppose that the validity of the genus *Megarrhiza* may still be seriously defended. The various new species of *Trifolium*, *Zauschneria*, etc., and the recast of *Krynitzkya*, *Plagiobothrys*, etc., into new forms may be safely left to the final judgment of competent botanists. Professor Greene's judgment and ours are widely divergent.

Dr. August Gattinger has issued, in a thick and neatly printed pamphlet of 109 pages, 8vo, *The Tennessee Flora, with special reference to the Flora of Nashville; Phœnogams and Vascular Cryptogams*, 1867.—The preface, full of pleasant personal details and grateful acknowledgments, is followed by a very interesting sketch of the general aspect of the flora of Tennessee and of its four natural floral arrondisements, which are graphically described, geographically, geologically and phytologically. We should be glad to quote the whole of it. Separate lists are given

of the "Plants of the glades and bluffs, of calcareous soils;" of the "Oak barrens and highlands, siliceous and argillaceous soils;" and of "Plants peculiar to West Tennessee," the eastern part of Cretaceous, the western of Tertiary and Post-tertiary deposits. Then comes the systematic catalogue, in which the species occurring within thirty miles of Nashville are printed in full faced type. Recently published species are given with characters in foot-notes.

Bulletin de la Société Botanique de France.—In the 33d volume M. Franchet begins his *Plantæ Yunnanses*, an account of the collections from the interior Chinese province of Yun-nan. Beginning in the fifth fascicle, it is carried on in the sixth through the *Anacardiaceæ*. M. Clos, having proposed the term *pistillodium* as the analogue of *staminodium*, M. Cogniaux, on p. 470, calls attention to his use of it in the Flora Brasiliensis, in 1878, and thinks the term as needful as staminodium. That is not quite clear; the latter term is free from ambiguity. Pistilodium may be the homologue either of a carpel or of a circle of carpels. M. Hérail and Blottière have a paper on the histology of the *Lardizabaleæ*. They come to the conclusion that De Candolle was probably right in appending this group to the *Menispermaceæ*, that, in any case, they are not *Berberidaceæ*.

Professor A. W. Eichler, Director of the Botanical Garden at Berlin (where he succeeded Alexander Braun), editor of the Flora Brasiliensis, a systematic botanist of the first class and a man most highly esteemed, died on the second of March, after a lingering illness. He was one of the foreign honorary members of the botanical section of the American Academy of Arts and Sciences.

M. Bornet delivered before the Academy of Sciences of the Institute of France, at the close of last year, a most appreciative notice of the late *L. R. Tulasne*, whose chair in the Academy he fills. It has now been published, and to it is appended a full list of Tulasne's publications.

Botanical Contributions, 1887 (a revision of some Polypetalous Genera and Orders, Sertum Chihuahuaense, Appendix, Miscellanea), by Asa Gray, are here mentioned only to state that a portion of the manuscript, accidentally omitted on p. 273, is supplied at the end, p. 314. Another grave oversight was not discovered in time. The paragraph in the middle of the page 299, beginning "*A. acerifolia*" was to have been erased from the printer's copy, being in fact replaced by the paragraph next below, beginning "*A. Thurberi.*" The lines printed by mistake have been cancelled by the pen in all or most of the distributed copies. A. G.

2. *Outlines of Classification and Special Morphology of Plants*, by Dr. K. Gœbel, Professor in the University of Rostock; a new edition of *Sachs' Text-Book of Botany, Book II.* Authorized English translation, by Henry E. F. Garnsey, Fellow of Magdalen College, Oxford. Revised by Isaac Bayley Balfour, M.A., M.D., F.R.S., Fellow of Magdalen College and

Sherardian Professor of Botany in the University of Oxford.—This work, published by the Clarendon Press, Oxford, in a large-paged octavo volume of 515 pages, is a great improvement upon the original of Sachs, not to speak of the advantage of having an independent volume apart from physiology and histology. Evidently the translator and reviser have done their part well. Perhaps it is too late to arrest such a misbegotten word as asexual meaning non-sexual; but Oxford University and the Clarendon Press might have lent a helping hand. The author himself, as appears from his introduction, was of doubtful mind as to the character, number and names of his primary group in the Vegetable Kingdom; so that his English representatives could not expect to help him. But he comes out essentially in a good old way with Thallophytes, Bryophytes, Pteriophytes or Vascular Cryptogams and Seed Plants (Spermaphytes). This, developed, recognizes a primary division into Phanerogams or Flowering and Cryptogams or Flowerless Plants; as to names, Flowering Plants is quite as good as Seed Plants, and long in use, and *Spermaphytes* is not such a name as the classical Endlicher would have made.

Coming to the classification of the Phanerogams, they are distributed, first into those without an ovary, *Gymnospermæ*, the third group of which, *Gnetaceæ* is said to have "flowers in many respects like those of Angiosperms," which is true and pertinent; second, Phanerogams with ovaries, *Angiospermæ*, A. *Monocotyledons*, B. *Dicotyledons*. Thus the Gymnosperms are taken to be what they are, whatever they may have come from, part and parcel of Phanerogamous plants; and, if the *Gnetaceæ* be of them, strictly connected with the Dicotyledons.

Finally, names and terms have some rights which ought to be respected. So we may protest against the present but probably fleeting fancy of imposing cryptogamous terminology upon phanerogamous botany, the new and ill-defined upon the old and well-settled. If all homologues must needs have the same name, why not call microspores "pollen," rather than pollen grains "spores?" This translation reads remarkably well; for the German has really been turned into English. It is not the translator's fault that we read that in the Cycads, "the branching of the primary root is monopodial," which is one way of saying that the branching is no branching at all. A plain writer would simply say such roots do not branch. A. G.

III. Astronomy.

1. *The Astronomical Journal.*—Eleven numbers of Dr. Gould's Journal have appeared since its resumption last autumn. It maintains the high character of the earlier volumes.

2. *Comets in* 1886.—In the tenth number of the *Astr. Jour.*, is given the following table:

Comets of the Year 1886.

The dates are in Greenwich M. T., and the elements only approximate.

Designation.	Discoverer.	Perihelion 1886.	Ω	ω	*i*	*q*	Discovery.	Synonym.	
I	Fabry	Apr. 5·96	36°23′	126°36′	82°37′	0·642	'85 Dec. 1	1885 *d*	
II	Barnard	May 3·28	68 19	119 36	84 25	0·479	Dec. 3	1885 *e*	
III	Brooks	May 4·67	288 6	39 1	100 33	0·842	'86 Apr. 30	1886 *b*	
IV	"	June 6·78	52 6	176 50	13 24	1·360	May 22	1886 *c*	periodic.
V	"	June 7·40	192 42	201 13	87 44	0·270	Apr. 27	1886 *a*	
VI	Finlay	Aug. 19·	101 56	174 8	14 27	0·883	Aug. 19	1886 *d*	Winnecke
VII	"	Nov. 22·39	52 26	315 7	3 2	0·998	Sept. 26	1886 *e*	periodic.
VIII	Barnard	Nov. 28·22	258 13	31 46	85 35	1·479	'87 Jan. 23	1887 *c*	
IX	"	Dec. 16·54	137 23	86 22	101 37	0·663	'86 Oct. 4	1886 *f*	

3. *Comets in* 1887.—The following are the comets discovered thus far in the present year:

Comet 1887*a*, discovered January 18th by Thome.
" 1887*b*, " January 23d by Brooks.
" 1887*c*, " January 23d by Barnard.
" 1887*d*, " February 16th by Barnard.

H. A. N.

4. In the same number of the *Astr. Jour.*, Professor Hall gives the result of his measurements of 63 small stars in the Pleiades. The probability that the stars of such a group have a common proper-motion, and that the small stars are connected physically with the larger ones, together with the importance of being able at some future time to test the motion of the brighter stars relative to the neighboring faint ones, led Professor Hall to undertake this series of observations. The triangulation of the bright stars of the Pleiades by Dr. Elkin, recently finished, made the present a favorable time for such measurements.

The improvement of the photographic processes is such, however, as to make it seem best for the present to discontinue these measurements and to wait to see what the photographic methods will furnish. H. A. N.

5. *Henry Draper Memorial.*—Professor Pickering has issued his first annual report of the photographic study of stellar spectra made at the Harvard College Observatory under the very liberal provision of Mrs. Draper as a memorial to her husband. The various investigations begun or devised are: 1. A catalogue of spectra of bright stars; 2. Catalogue of spectra of faint stars; 3. Detailed study of the spectra of bright stars; 4. Faint stellar spectra; 5. Absorption spectra; 6. Wave lengths. The progress already made in spectral photography is vividly illustrated by the plate which accompanies the Report. H. A. N.

6. *U. S. Coast and Geodetic Survey, for the year ending with June,* 1885. Washington, 1886.—This report contains, among the results of work accomplished, papers by C. A. Schott on the magnetic dip and intensity with their secular variation and geographical distribution in the United States, with three maps and

three plates; GEORGE DAVIDSON, collection of some magnetic variations off the coast of California and Mexico, observed by Spanish Navigators in the last quarter of the 18th century; WM. FERREL, on the harmonic analysis of the tides at Governor's Island, New York Harbor; Lieut. J. E. PILLSBURY, U. S. N., on deep-sea current work in the Gulf Stream; C. S. PEIRCE, on the influence of a noddy on the period of a pendulum, and on the effect of unequal temperature upon a reversible pendulum.

Magnetic dip in North America.—Mr. Schott, in Part II of his paper, mentions Prof. Loomis's deduction as to the diminution of magnetic dip based on observations from 1819 to 1839, making it 1·5′ per year; and again, "comparing the dips in N. York by Sir E. Sabine and Sir J. Franklin (1822 to 1825) with his own and others about the epoch 1835, deducing the rate of 2·1′ per year, and thence, including also the earlier observations, a rate of 1·8′ as the annual diminution of dip in the Eastern United States. Mr. Schott then observes that in 1856 he showed that in the northeastern part of the country the dip continued to decrease till about the year 1843, when it became stationary, 1842·7±0·7, being deduced as the period of the minimum; that from that date to 1856, the increase had been 2·7′. But unexpectedly the increasing of the dip stopped about 1859 in the Eastern United States, and that since about 1860, a decrease has been in progress "thus suggesting the idea of a secondary motion or wave of comparatively short duration, and of a character opposite to the general motion in the variation of the dip as it existed before and after this temporary interruption." The time was the same at Toronto and Washington, but much later on the Pacific in Southern California. After a further discussion of the subject, Mr. Schott gives as the annual decrease in seconds for Cambridge and Boston, 7·5; New Haven, 5·6; Albany and Greenwich, 6·6; New York, 5·4; Philadelphia, 5·5; Baltimore, 4·8; Washington, 3·5; Toronto, 2·5; Cleveland, 3·6; Detroit 2·8; Saint Louis, 5·0, "which values, in the absence of any additional observations, may be used for a few years to come."

At Rio de Janeiro there has been a steady increase of north dip between La Caille's observation in 1751 (dip $=-20°\ 0'$) and Harkness's observation in 1866 ($-11°\ 47'$). The same is noted in Valparaiso, between the observations of Malaspina in 1793 (dip$=-44°\ 58'$), and Harkness's observation in 1866 ($-35°\ 23'$). In contrast with this, at Havana the present annual change is probably less than $+0·8'$: at Acapulco about $+1·0'$; at Mexico and San Blas, perhaps, $+1·5'$ to $+2·0'$. "At Magdalena Bay, Lower California, the annual change seems to have become zero at present."

In British N. America, North of Dakota over the Lake Winnipeg region to Hudson's Bay, it is not now very different from what it was forty years ago; farther west at Fort Chipewyan, Fort Edmonton, it may be about $-0·5'$; at Nootka Sound, Vancouver Island, about $-0·7'$; at Port Simpson, $-1·5'$; in Alaska,

decreasing since (about) 1852, with an annual rate between $-2{\cdot}2'$ at Sitka, $-1{\cdot}5'$ at Unalashka, $1{\cdot}0'$ at Port Clarence near Bering Strait, and $1{\cdot}2'$ at Point Barrow. Crossing to Asia, the dips indicate a maximum about 1854, which appears to be supported by the dips at Port Clarence, and has been conjectured for Unalashka.

The position of the pole of the vertical dip was deduced by Ross, as follows: in June, 1831 in φ 70° 05·3′, $\lambda = -96°$ 45·8′. Mr. Schott observes, "It seems perhaps more reasonable to suppose its range of displacement to be quite limited than to assign to it, as has been done, a path surrounding the geographical pole, and to be described in several centuries." "Observations on H. M. S. Brazen in 1813 point to approaching verticality in $\varphi = 69°$ and $\lambda = -92°$;" and "Lieut. Schwatka supposes the pole in 1879 to have shifted to $\lambda = -99°$ 35′, while he leaves any change in its latitude undecided." Mr. Schott adds, "If the secular diminution extends to this northern region, the pole would now be found in a higher latitude than that given by Ross, but of this we are not certain. It is to be regretted that no steps were taken toward its solution in connection with the late international circumpolar explorations."

The first 125 pages of Mr. Schott's able paper are occupied with a tabulation and discussion of observations; and Part third treats of the secular variations of the horizontal component of the magnetic force and of the total intensity in the United States, and contains a table of the annual value of observed magnetic horizontal force at prominent stations.

IV. Miscellaneous Scientific Intelligence.

1. *Die Hochseen der Ostalpen.*—Dr. August Böhm has given in a recent publication of the Vienna Geographical Society an interesting discussion of the distribution of lakes on the earth's surface. Alluding to the recognized fact that lakes occur for the most part in groups and as connected with glacial phenomena, he goes on to show that there is a connection between their situation and their altitude. In other words, it may be shown that the height of the mountain lakes above the sea, in general, increases as we go from the pole toward the equator, somewhat as the snow level rises. The Alpine lakes, which give the data for this discussion, are divided into two groups, the valley and mountain lakes. The former are in general large and occupy the valley bottoms, forming a horizontal zone among themselves; they lie on the circumference of the former glacial region, where the ice streams at the time of maximum glaciation could exert their greatest force. The latter are generally small and are situated high up in the heart of the mountain region, but they also occur in greatest abundance at a definite altitude in each mountain chain, marking the last phase of the retreat of the shrinking glaciers. These mountain lakes are regarded as having but an ephemeral nature; the filling of the lake with detritus and the

deepening of its outflow channel so as to drain it being the two causes at work to destroy these bodies of water. Attention is called to the fact that within the last century 100 lakes have disappeared in Tyrol. With the retreat of the glaciers the upper lake zone also retreats to a continually higher level, until a limit is reached as determined by the precipitous character of the mountains. The rise in altitude of the present lake-zone from pole to equator is connected with the fact that glaciation has been more marked in higher latitudes. The author discusses in detail the distribution of the lakes and their character in the Eastern Alps, and then gives a tabulated list of them arranged according to their vertical distribution at intervals of 100 meters. This brings out clearly the concentration of these lakes at certain levels, and this is made still more striking in a graphical chart. The following table gives some of the facts in condensed form:

	3000	3000-2500	2500-2000	2000-1500	1500-1000	1000-500	500-0
Limestone Alps—North,	0	2	36	84	71	122	5
Schist Alps—North,	0	6	46	27	2	7	0
Gneiss Alps—Cent. chain,	1	372	771	312	38	21	1
Limestone Alps—South,	0	8	100	71	41	28	21

2. *American Association.*—It has been decided to hold the meeting of the American Association for the Advancement of Science, for this year at New York, commencing on August 10th.

3. *Agriculture in some of its relations with Chemistry;* by F. H. Storer, S.B., A.M., Prof. Agric. Chem. Harvard Univ. 2 vols. 8vo. New York, 1887. (Charles Scribner's Sons).—A notice of this excellent work by the able chemist of the Harvard Agricultural School is deferred to another number.

4. *National Academy of Sciences.*—The following papers were entered to be read at the meeting held at Washington, April 19–22:

T. Sterry Hunt: On Chemical Integration.

C. E. Dutton and E. Hayden: Results of the Investigation of the Charleston Earthquake.

Joseph LeConte: On some Phenomena of Binocular Vision.

W. G. Farlow: The Vegetation of the Hot Springs of the Yellowstone Park.

E. D. Cope: On the Fore Limb and Shoulder Girdle of Eryops, and on the Vertebrates of the Triassic.

Elias Loomis: Rainless character of the Sahara.

S. P. Langley: The Color of the Sun; a new Map of the Spectrum.

Ira Remsen: Chemical Constitution and Taste; On a New Class of Compounds analogous to the Phthaleins; On the Decomposition of Diazo Compounds by Alcohol.

A. G. Bell: On the Ancestry of the Deaf; On the Notation of Kinship.

J. W. Gibbs: On the Determination of Orbits of Planets and Comets.

G. H. Williams: On the Serpentine of Syracuse, New York.

A. W. Greely: On the Barometric Oscillation—Diurnal and Annual.

W. H. Dall: On Floridian Geology.

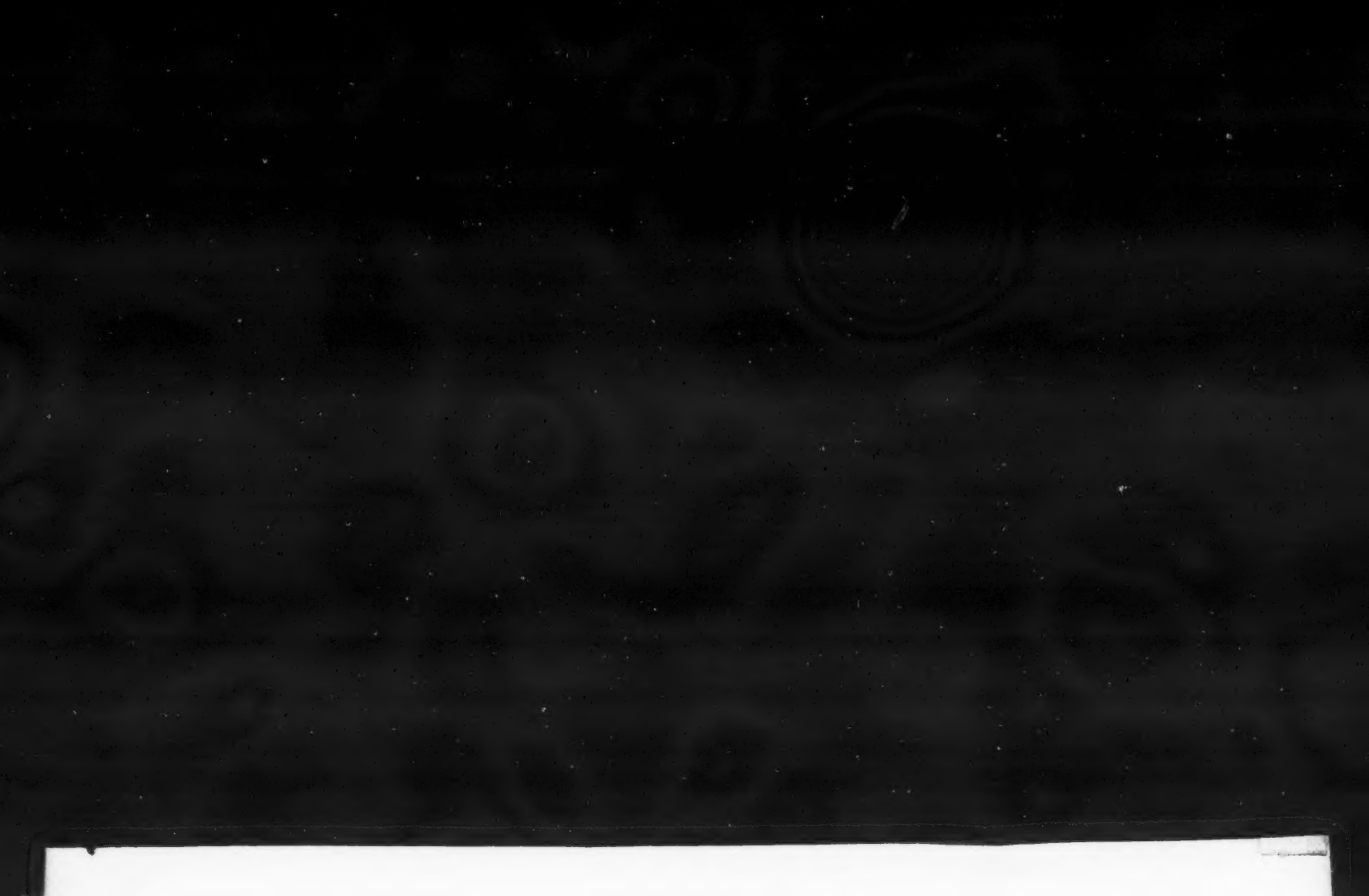
C. D. Walcott: On the Taconic System of Emmons.

R. D. Irving: Is there a Huronian Group?

B. G. Wilder: On the Brain of the Ceratodus, with Remarks on the General Morphology of the Vertebrate Brain.

Theodore Gill: Outline of the Ichthyological System.

A. W. Wright: The effect of Magnetization on the Electrical Resistance of Metals.



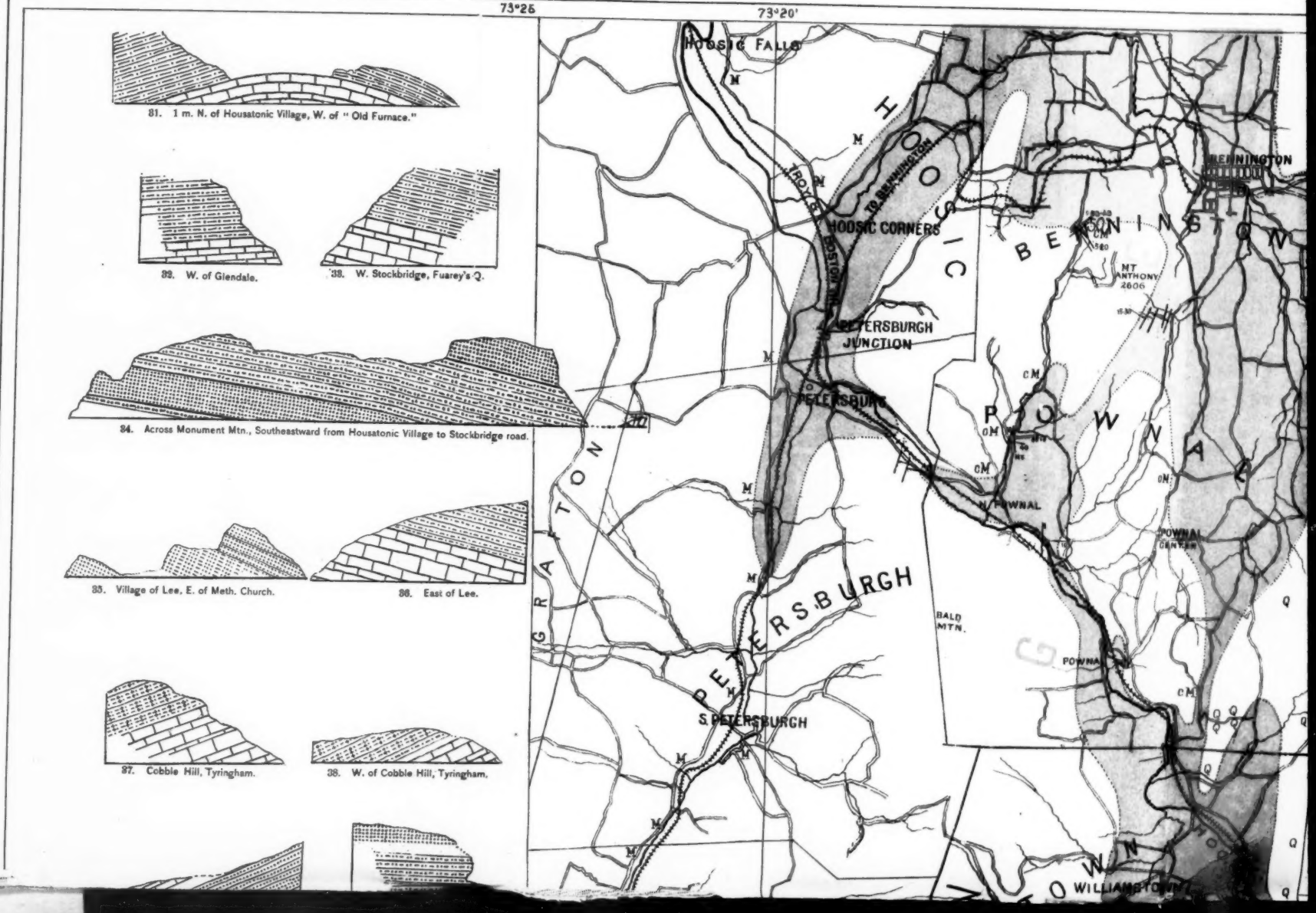
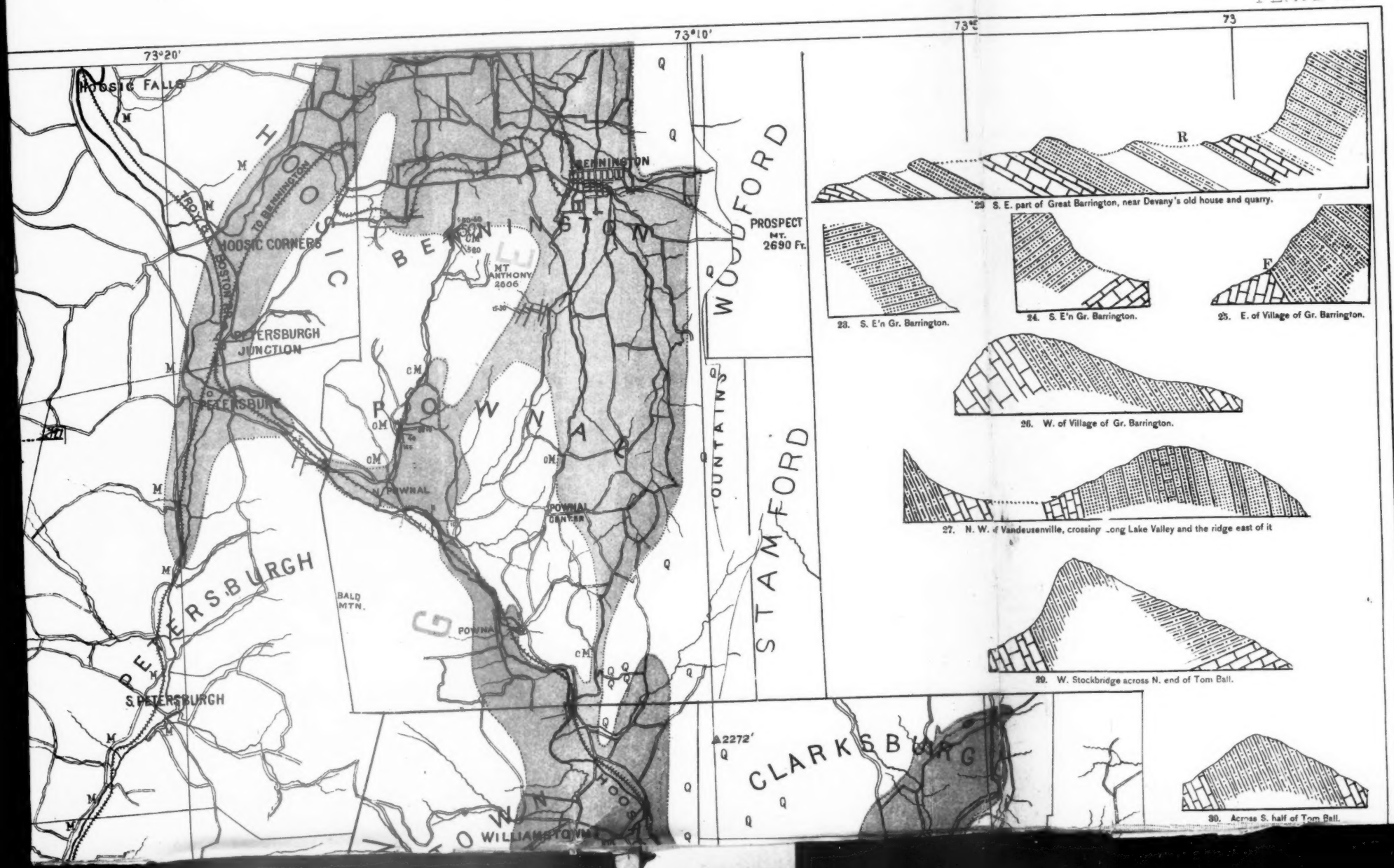
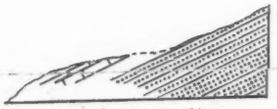

73°25
73°20'
HOOSIC FALLS
HOOSIC CORNERS
TO BENNINGTON
TROY & BOSTON R.R.
PETERSBURGH JUNCTION
PETERSBURGH
S. PETERSBURGH
GRAYTON
HOOSIC
BENNINGTON
BENNINGTON
MT ANTHONY 2606
POWNAL
N. POWNAL
POWNAL CENTER
BALD MTN.
WILLIAMSTOWN
31. 1 m. N. of Housatonic Village, W. of "Old Furnace."
32. W. of Glendale.
33. W. Stockbridge, Fuarey's Q.
34. Across Monument Mtn., Southeastward from Housatonic Village to Stockbridge road.
35. Village of Lee, E. of Meth. Church.
36. East of Lee.
37. Cobble Hill, Tyringham.
38. W. of Cobble Hill, Tyringham.

PLATE XI

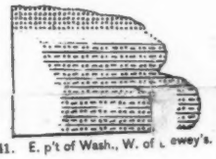

73°20'
73°10'
73°
73
HOOSIC FALLS
HOOSIC CORNERS
TO BENNINGTON
BOYLSTON
BOSTON R.R.
PETERSBURGH JUNCTION
PETERSBURGH
S. PETERSBURGH
BENNINGTON
BENNINGTON
MT ANTHONY 2606
PROSPECT MT. 2690 Ft.
WOODFORD
POWNAL
N. POWNAL
POWNAL CENTER
BALD MTN.
STAMFORD
MOUNTAINS
CLARKSBURG
2272'
WILLIAMSTOWN
R
23. S. E. part of Great Barrington, near Devany's old house and quarry.
23. S. E'n Gr. Barrington.
24. S. E'n Gr. Barrington.
F
25. E. of Village of Gr. Barrington.
26. W. of Village of Gr. Barrington.
27. N. W. of Vandeusenville, crossing ..ong Lake Valley and the ridge east of it
29. W. Stockbridge across N. end of Tom Ball.
30. Across S. half of Tom Ball.

37. Cobble Hill, Tyringham.

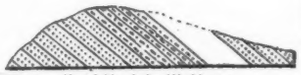
38. W. of Cobble Hill, Tyringham.



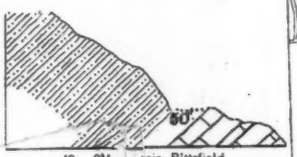
40. Southern part of Lee.



41. E. p't of Wash., W. of [illegible]owey's.

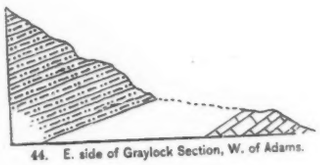


42. Ashley Lake, Washington.

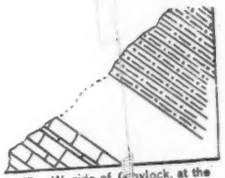


43. Sh[illegible]ain, Pittsfield.

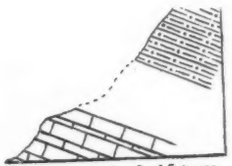
42°40'



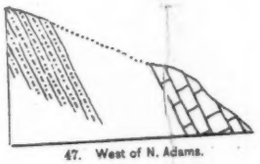
44. E. side of Graylock Section, W. of Adams.



45. W. side of Graylock, at the Hopper, Willi[illegible]town.

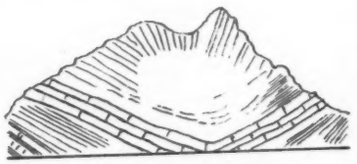


46. Same as 45, but S. of Entrance.

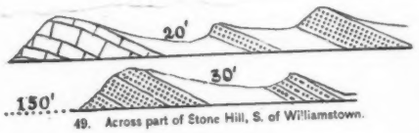


47. West of N. Adams.

42°35'

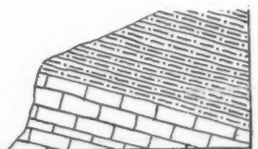


48. Graylock Section, after Emmons.



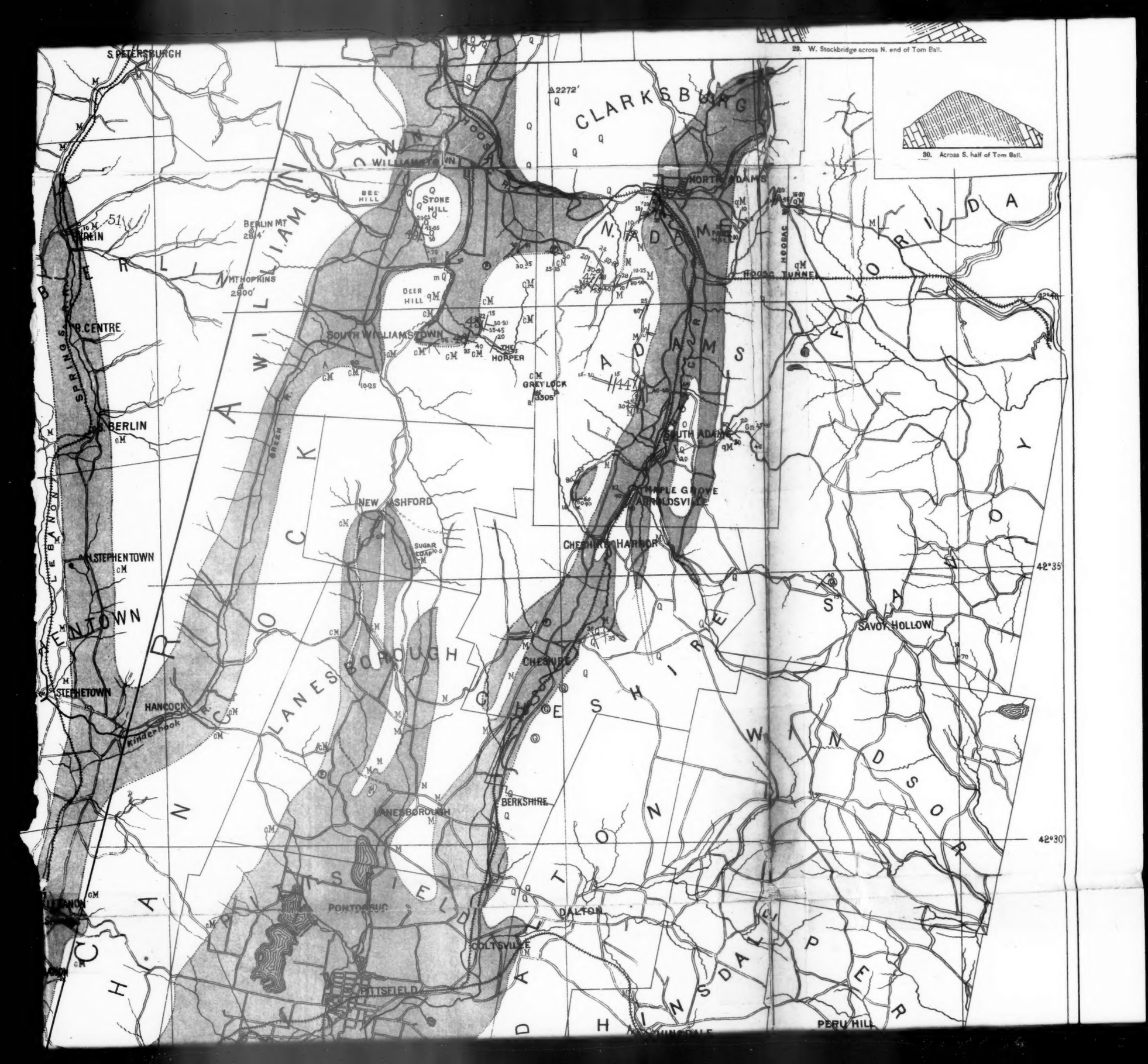
49. Across part of Stone Hill, S. of Williamstown.

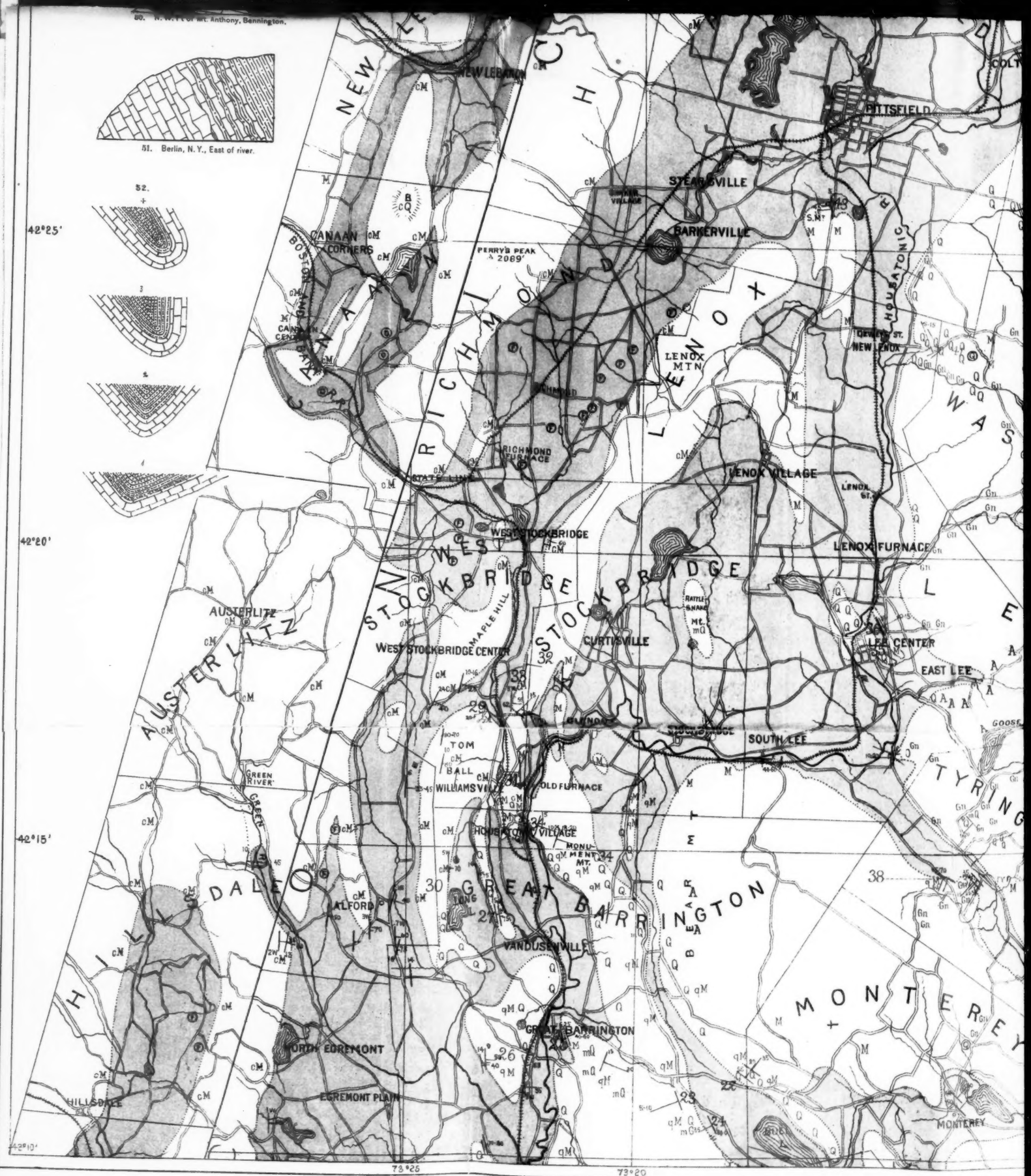
42°30'



50. N.W. f't of Mt. Anthony, Bennington.

51. Berlin, N.Y., East of river.


29. W. Stockbridge across N. end of Tom Ball.
30. Across S. half of Tom Ball.
S. PETERSBURGH
CLARKSBURG
WILLIAMSTOWN
NORTH ADAMS
BEE HILL
STONE HILL
BERLIN MT
MT HOPKINS
DEER HILL
SOUTH WILLIAMSTOWN
HOOSAC TUNNEL
HOPPER
GREYLOCK
S. BERLIN
NEW ASHFORD
SUGAR LOAF
STEPHENTOWN
HANCOCK
Kinderhook
LANESBOROUGH
CHESHIRE
BERKSHIRE
PONTOOSUC
DALTON
COLTSVILLE
PITTSFIELD
SAVOY HOLLOW
PERU HILL
42°35'
42°30'
BERLIN
SPRINGS
CENTRE
LEBANON
HANCOCK
ADAMS
FLORIDA
SAVOY
WINDSOR
HINSDALE
UPPER


80. N. W. Pt. of Mt. Anthony, Bennington.
51. Berlin, N.Y., East of river.
52.
42°25'
42°20'
42°15'
42°10'
73°25
73°20
NEW LEBANON
PITTSFIELD
STEARNSVILLE
BARKERVILLE
CANAAN
CANAAN CORNERS
PERRY'S PEAK
2089'
BOSTON & ALBANY R.R.
HOUSATONIC R.R.
LENOX MTN
LENOX
RICHMOND
RICHMOND FURNACE
STATE LINE
LENOX VILLAGE
NEW LENOX
LENOX FURNACE
WEST STOCKBRIDGE
STOCKBRIDGE
AUSTERLITZ
MAPLE HILL
WEST STOCKBRIDGE CENTER
CURTISVILLE
RATTLESNAKE Mt.
LEE
LEE CENTER
EAST LEE
SOUTH LEE
TYRINGHAM
GOOSE
TOM BALL
WILLIAMSVILLE
OLD FURNACE
GREEN RIVER
GREEN
HOUSATONIC VILLAGE
MONUMENT MT.
HILLSDALE
ALFORD
TONG
GREAT BARRINGTON
VANDUSENVILLE
NORTH EGREMONT
EGREMONT PLAIN
HILLSDALE
MONTEREY

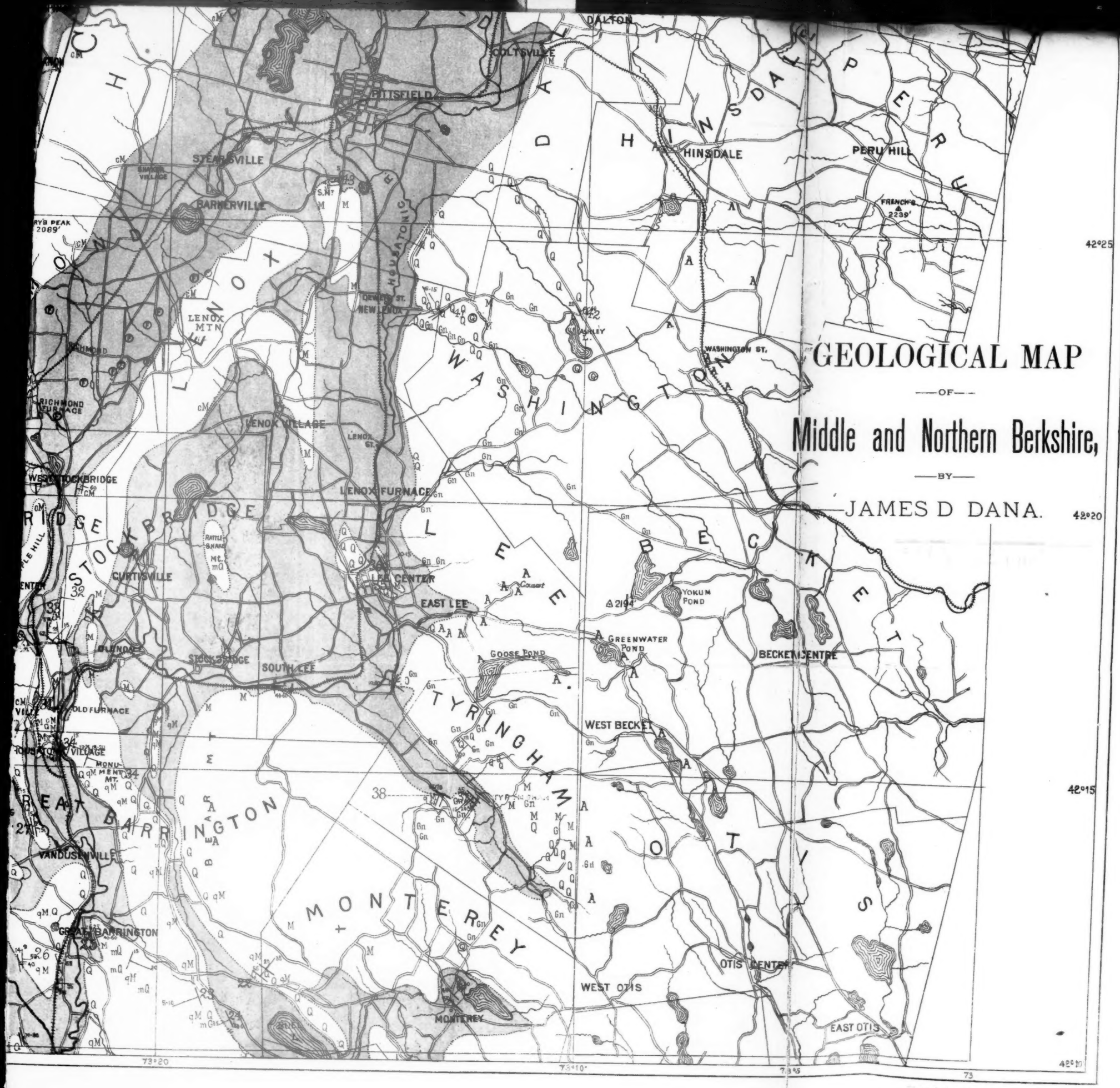
GEOLOGICAL MAP

—OF—

Middle and Northern Berkshire,

—BY—

JAMES D DANA.



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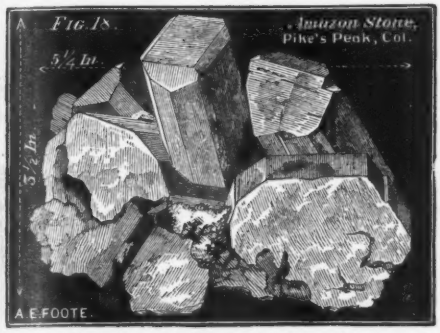

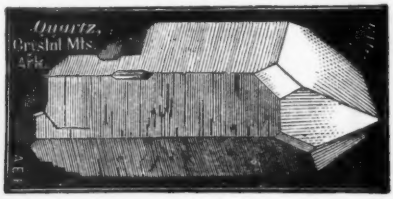

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Vol. xxxiii, p. 291, in foot-note, Jahrb. Berg-Hütt., for "1877" read "1887."